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DIOGO A. SYMONS, M.INST.C.E.,

First President (1910) of The Society of Engineers (Incorporated).

(See page vi.)

(THE)
SOCIETY OF ENGINEERS
INCORPORATED
(INCORPORATED).

SOCIETY OF ENGINEERS: ESTABLISHED MAY, 1854	}	AMALGAMATED AND
CIVIL & MECHANICAL ENGINEERS' SOCIETY: FOUNDED MAY, 1859		INCORPORATED 1910.

Journal and
TRANSACTIONS FOR 1910.

EDITED BY
A. S. E. ACKERMANN, B.SC.(ENG^o.),
A.C.G.I., A.M.INST.C.E., M.R.S.I.
SECRETARY.

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LONDON:
PUBLISHED BY THE SOCIETY OF ENGINEERS
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1910.

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ERRATA.

Page 10, line 9. The formula should read :

$$HP = av^3 \div 150,000.$$

Plate facing p. 11. " Buckenhall " should read : " Buckenhill."

The Society is not responsible either for the statements made or for the opinions expressed in the papers or in the discussions thereon.

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PLACE OF MEETING.

CAXTON HALL, WESTMINSTER.

PAPERS AND PREMIUMS.

THE Council of The Society of Engineers invite original communications from members, as well as from gentlemen who do not belong to the Society, on subjects connected with any branch of Engineering.

For any papers published in the JOURNAL that may be considered sufficiently meritorious the Council may at their discretion award one or more of the following Premiums, viz. :—

1. THE PRESIDENT'S GOLD MEDAL, of the value of Five Guineas, given annually by the President.
2. THE BESSEMER PREMIUM, provided for annually by the late Sir Henry Bessemer, F.R.S., Honorary Member, of the value of Five Guineas.
3. THE WILLIAM CLARKE PRIZE, provided by Mr. William Clarke, M.Inst.C.E., Hon.F.S.E., for past members of the Civil and Mechanical Engineers' Society; value Five Guineas.
4. THE NURSEY PREMIUM, value Three Guineas, founded as a memorial to the late Perry F. Nursey.
5. THE BERNAYS PREMIUM, value Three Guineas, provided by the late Mr. Joseph Bernays.
6. THE SOCIETY'S PREMIUMS, given annually by the Society, of an aggregate value not exceeding Twenty Pounds.
7. THE STATUS PRIZE (see opposite page).

The number and value of the Society's Premiums are decided by the Council according to the number of meritorious papers published during the year.

Members of Council are disqualified by the provisions of the By-Laws from receiving Premiums.

THE STATUS PRIZE.

The Status Prize may be awarded by the Council each year for the next three years ending 1913 (if papers of sufficient merit are received) for the best paper written by any person on the subject of "How to Improve the Status of Engineers and Engineering, with special reference to Consulting Engineers." The prize for the year 1910 will consist of books and/or instruments, selected by the author of the premiated essay, to the value of three guineas.

The essay shall be written in the third person, shall contain not fewer than 4,000 nor more than 6,000 words, and shall be typed on one side only of foolscap paper, the distance between the lines being $\frac{3}{8}$ inch or more.

All essays submitted in competition for this prize and the copyright therein shall become the property of the Society, but the donor also shall have the right of publishing such essays or any part thereof.

The Council of the Society may, at their discretion, permit the publication of any essay by its author, on such conditions as they may think fit to require.

The premiated essay shall be read and discussed at a meeting of the Society, the reading being done by the author if possible, and such essay shall be published in the usual manner in the Society's Journal, the author being entitled to receive 50 copies of his paper upon publication thereof.

The prize shall not be awarded to any Member of Council or Officer of the Society.

Essays sent in for competition must be received by the Secretary on or before May 31st, in each year.

DIOGO A. SYMONS.

FIRST PRESIDENT OF THE SOCIETY OF ENGINEERS (INCORPORATED).

The subject of this short biography, whose portrait forms the frontispiece, served a five years' pupilage with MM. Glover and Hobson, Mechanical Engineers and Millwrights, of Bermondsey, and afterwards received a scientific training at the Crystal Palace School of Practical Engineering. Subsequently he became assistant to the late Mr. James Walker, M.Inst.C.E., and was engaged on very heavy constructional work in connection with the Isle of Man Harbour Works, returning to the Crystal Palace School in 1893 in the capacity of Instructor of the Advanced Civil Engineering Section. From 1897 to 1901 he was employed on railway construction and the design and erection of steelwork. In the latter year he commenced practice as a consulting engineer in Westminster, the schemes with which he has been associated including the water supply for Athens, at an estimated outlay of £1,500,000; improvements in the water supply of Dieppe; the water supply and drainage of Maceio, Brazil (£360,000) and many other important works.

Mr. Symons is consulting engineer to the well known firm of J. C. & J. Field, Ltd. of London and Rainham, Essex, and to the Society of Motor Manufacturers and Traders, while he has recently reported upon a comprehensive scheme of railway development in Spain, the estimated cost of which is £1,300,000. Mr. Symons was elected a Member of the Institution of Civil Engineers in 1906, and has been connected with the old Society of Engineers from 1891 until he became first President of the incorporated Society in 1910.

January 19th, 1910.

DINNER

CELEBRATING THE AMALGAMATION OF THE

SOCIETY OF ENGINEERS

AND THE

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

THE amalgamation of the above-named Societies, which has received the hearty support of the members as evidenced by their voting, was fittingly celebrated by a reception, dinner and programme of music at the Waldorf Hotel, London, on Wednesday, January 19th, 1910. This function took the place of the usual annual dinner of the Society of Engineers which was to have been held on December 15th, 1909, but which, in view of the approaching union of the two Societies, was dispensed with.

Nearly 200 members and guests, including a number of ladies, shewed by their presence their interest in the event, unique in the history of engineering, of the amalgamation of two Societies, each of more than 50 years standing. The guests were received by Mr. E. J. Silcock, M.Inst.C.E., F.S.I., F.G.S., last President of the Society of Engineers, who was accompanied by his wife, and by Mr. W. Noble Twelvetrees, M.I.Mech.E., last President of the C.M.E.S., who was accompanied by Mrs. Herbert Twelvetrees. Among the distinguished guests who were present may be mentioned Sir W. H. M. Christie, K.C.B., F.R.S., Astronomer Royal, who was accompanied by his daughter, Mrs. Paget Palmer; Sir R. Douglas Powell, Bart., K.C.V.O., M.D., President of the Royal College of Physicians, and Mrs. Leadam; Sir William Church, K.C.B., M.D., President of the Royal Society of Medicine; Mr. H. T. Butlin, D.C.L., President of the Royal College of Surgeons; Sir Joseph Larmor, M.A., D.Sc., LL.D., and Dr. J. R. Bradford, F.R.C.P., F.R.S., Secretaries of the Royal Society; Dr. Gisbert Kapp, M.Inst.C.E., President of the Institution of Electrical Engineers; Professor W. R. Smith, M.D., D.Sc., D.P.H., Principal of the Royal Institute of Public Health; Mr. Stanley Machin, Chairman of the London Chamber of Commerce, and Mrs. Machin; Mr. Oliver Imray, President of the Chartered Institute of Patent Agents, and Mrs. Imray; Mr. John Bell Simpson, M.Inst.C.E., President of the Institution of

Mining Engineers, Mr. W. Nisbet Blair, M.Inst.C.E., President of the Incorporated Association of Municipal and County Engineers; Mr. Ernest George, A.R.A., President of the Royal Institute of British Architects, and Miss George; Mr. H. B. Searles-Wood, F.R.I.B.A., Chairman of the Royal Sanitary Institute, who brought his wife; Professor C. Vernon Boys, F.R.S.; Mr. M. Holroyd-Smith, M.I.E.E.; Mr. William Clarke, M.Inst.C.E., Hon. Member of the Civil and Mechanical Engineers' Society, and Mrs. Colin Campbell; Mr. L. Pendred, Editor of "The Engineer," and Mrs. Pendred; Mr. H. H. Statham, F.R.I.B.A., Editor of "The Builder," and Miss Statham; Mr. T. T. Blyth, Hon. Solicitor of the Society of Engineers, and Mrs. Blyth; and Mr. R. L. Matthews, Hon. Auditor of the Civil and Mechanical Engineers' Society, who was accompanied by Miss Doris Scott.

The guests who had accepted invitations but were prevented by illness and other causes from attending included Mr. James Swinburne, F.R.S.; Mr. W. H. Prescott, A.M.Inst.C.E., M.I.Mech.E., President of the Institute of Sanitary Engineers; and Mr. R. H. Willcocks, LL.B., Hon. Solicitor of the Civil and Mechanical Engineers' Society.

During the reception which preceded the dinner the Members of Council of the two constituent Societies who were present assisted in introducing the guests.

The Council of the Civil and Mechanical Engineers' Society was represented by Mr. W. Noble Twelvetees, M.I.Mech.E., A.M.I.E.E., last President of the Society; Messrs. Thomas Cole, A.M.I.C.E., E. H. G. Brewster, A.M.Inst.C.E., M.I.Mech.E., C. T. Walrond, A.M.Inst.C.E., A.M.I.E.E., and W. B. Esson, M.Inst.C.E., M.I.E.E., Past Presidents; Mr. E. Ault, M.I.Mech.E., F.S.I., Vice-President; Mr. W. W. Hind-Smith, F.R.G.S., and Dr. J. S. Owens, B.A., A.M.Inst.C.E., Members of Council; while the Members of Council of the Society of Engineers present included Mr. E. J. Silcock, M.Inst.C.E., F.S.I., F.G.S., the last President; Messrs. J. Patten Barber, M.Inst.C.E.; D. B. Butler, A.M.Inst.C.E.; Maurice Wilson, A.M.Inst.C.E.; J. W. Wilson, M.Inst.C.E., M.I.Mech.E.; W. Worby Beaumont, M.Inst.C.E., J. C. Fell, M.I.Mech.E.; Percy Griffith, M.Inst.C.E.; Arthur Rigg and A. T. Walmisley, M.Inst.C.E., F.S.I., Past Presidents; Messrs. F. G. Bloyd, A.M.I.Mech.E., and A. G. Drury, M.Inst.C.E., Vice-Presidents; and Messrs. John Kennedy, W. A. Valon, A.M.Inst.C.E., H. C. H. Shenton, T. E. Bower, R. W. A. Brewer, A.M.Inst.C.E., M.I.A.E., and Norman Scorgie, M.Inst.C.E., Members of Council. The President of the New Society, Mr. Diogo A. Symons, M.Inst.C.E., M.I.Mech.E., was also present, as was Mr. A. S. E. Ackermann, B.Sc.(Engineering), A.M.Inst.C.E., who has been Hon. Secretary of the Civil and Mechanical Engineers' Society since 1898, and Secretary of the Society of Engineers since July, 1907.

Dinner was served in a richly decorated room adjoining the Palm Court, the tables being tastefully adorned with flowers. Mr. E. J. Silcock was in the chair and Mr. W. N. Twelvetrees occupied the Vice-Chair. Towards the conclusion of the dinner the toast of "The King" was proposed by the Chairman and that of "The Queen, the Prince and Princess of Wales, and other members of the Royal Family" by the Vice-Chairman, both toasts being received with musical honours. **Professor C. Vernon Boys, F.R.S.**, proposing the toast of "Applied Science," said that the time had long gone by when applied mathematics and applied science were held to be something to be ashamed of. Applied science, like pure science, had this advantage, that those who were devoted to it had the finest possible opportunity for the exercise of their creative, inventive and constructive faculties. The engineer was essentially constructive either with material or with ideas; it was rarely that he was destructive, that being the business of the military engineer as distinct from the civil engineer.

Sir Richard Douglas Powell, K.C.V.O., M.D., responding to the toast, remarked that one could not get away from applied science. At a dinner such as they had that evening, agricultural and horticultural science combined to provide the repast and grace the tables; viticultural science gave them the wines in which the toasts were drunk, and the culinary art enabled them to apply gastronomical science to the food that had been before them on the tables; he hoped sincerely that none of them would in consequence have need to call in the aid of medical science. Most of those who were present in the room were engaged in the application of engineering science, and so one might go on to name innumerable other sciences. He would say no more except to congratulate the two Societies upon having combined, and to assert that he had every confidence that they would derive strength from the union, as in the case of the various medical associations which had united and were represented there that evening by his honoured friend Sir William Church, the President of the Royal Society of Medicine.

Mr. E. J. Silcock, M.Inst.C.E., F.S.I., F.G.S., last President of the Society of Engineers, said he had to propose the toast of the evening, "Success to the New Society." Never before in the history of engineering had two Societies, each of which had completed more than half a century of active existence, been amalgamated. The two Societies whose union they were celebrating that evening had been running for fifty years upon nearly parallel lines and with similar objects, and he might add, in very friendly relationship. It was not until the death of their last Secretary, Mr. Perry F. Nurse, that the suggestion of the amalgamation had been brought forward. The Council had appointed Mr. A. S. E. Ackermann to succeed Mr. Nurse, and it was largely due to the good offices of the former, who had been Hon. Secretary

of the Civil and Mechanical Engineers' Society for several years, that an *entente cordiale* had been developed into an actual union ; a step which he hoped would improve the standing and usefulness of both. He would like to pay a tribute to the services rendered by Mr. Percy Griffith, Mr. W. N. Twelvetrees, Mr. J. W. Wilson and other members of the two Councils, who had been ably seconded by the Honorary Solicitors, Mr. T. T. Blyth (of Messrs. Blyth, Dutton, Hartley & Blyth) and Mr. R. H. Willcocks (of Messrs. Bridgman & Willcocks).

The Chairman concluded by outlining the history of the Society from the time of its formation as the "Putney Club" in May, 1854, and paid a tribute to all those eminent members of the profession who in one way or another had contributed to the advancement of the Society since its establishment.

Mr. W. Noble Twelvetrees, last President of the Civil and Mechanical Engineers' Society, supporting the toast, referred to foundation of the Society he represented by the pupils and draughtsmen of Messrs. Ravenhill & Co., marine engineers of Ratcliff, in the year 1859, the first President being Mr. G. W. MacGeorge, who, after wishing the forthcoming amalgamation success, had died in Sept., 1909, while Mr. A. F. Yarrow, M.I.C.E., was the first Vice-President. The first paper of which a record remained was one on "Railway Curves," read by Mr. Walter Rutt in December, 1859. He was glad to congratulate Mr. Rutt, who was now Chief Engineer for Railways under the South Australian Government and an Hon. Member of the Society, on having been identified with the Society without a break for more than 50 years. Mr. W. H. Maw, the editor of "Engineering," a Past President of the Institution of Mechanical Engineers, was also among their first members, as was Mr. G. J. Crosbie Dawson, M.Inst.C.E., engineer to the North Staffordshire Railway. Among others who had rendered service to the Society in the past and were still its supporters might be mentioned Mr. Eedes Eachus, Mr. R. E. Cooper, Baron Siccama, Mr. G. W. Willcocks, Chief Engineer to the L. G. B., and Mr. A. T. Walmisley, M.Inst.C.E. Mr. E. H. G. Brewster had been a zealous member of the Society, had regularly attended the meetings for more than 37 years, and was present that evening with Mr. C. T. Walrond, M.Inst.C.E. (who for the past 10 years had been Hon. Treasurer), and Mr. William Clarke, M.Inst.C.E., one of their oldest members and recently elected an Hon. Member. He had pleasure in giving publicity to the fact that Mr. Clarke had generously offered a donation of five guineas for the encouragement of the junior members of the Society. Two architects had occupied the Presidential Chair and six architects had held other offices. He believed that the amalgamation of the two Societies had been proposed at diverse times by Mr. A. T. Walmisley and Professor Henry Adams, both of whom had been Presidents of

both Societies. The thanks of the two Societies were due to Professor Henry Adams, who was Chairman of the Joint Committee which settled the basis upon which the amalgamation was eventually effected. Thanks were also due to Mr. E. J. Silcock and other members of the Society of Engineers, among whom he would especially name Mr. J. W. Wilson, their indefatigable Past-President, and also Mr. T. T. Blyth, Hon. Solicitor of that Society. They owed a great debt of gratitude to Mr. R. H. Willcocks, who had been Honorary Solicitor of the C.M.E.S. for 44 years and had rendered valuable services. He heartily wished prosperity to the new Society and desired to couple with the toast the name of its first President, Mr. Diogo A. Symons, M.Inst.C.E., and to wish him a most successful year of office.

Mr. A. S. E. Ackerman read the following remarks on behalf of **Mr. Symons**, who was suffering from indisposition.

Mr. Chairman, Vice-Chairman, Ladies, and Gentlemen,—I sincerely thank Mr. Silcock and Mr. Twelvetrees for the kind way they have proposed this toast, and also I thank you for the cordial way it has been received.

The amalgamation is now an accomplished fact and is a source of congratulation to all concerned, great credit being due to those particular gentlemen who have brought this matter to a successful issue.

The engineering profession is involved in many issues, and to my mind one of the most important is that unity should exist between the various institutions. I consider that by this amalgamation a progressive policy has been adopted which should be of advantage to the whole profession.

I must thank those gentlemen who are responsible for my being the first President of the new Society; I fully esteem the honour they have conferred on me, and although I naturally realize my responsibilities, I am relieved to know that I have the co-operation of a hard-working Council. I should like to mention that the session begins next month, and I understand that a number of interesting papers will be read. In view of this I hope the meetings will be well attended by the members and their friends.

Mr. A. T. Walmisley proposed the toast of "Kindred Institutions," and coupled with it the names of Dr. Gisbert Kapp, M.Inst.C.E., President of the Institution of Electrical Engineers, and Mr. Ernest George, A.R.A., President of the Royal Institute of British Architects.

Dr. Gisbert Kapp thanked those present for the cordial way in which they had honoured this toast. The ancient guilds of craftsmen were very chary in admitting members, and looked upon each other with suspicion, but the modern engineering societies received members with open arms. Naturally they looked to the older Societies for guidance. The Institute of Civil Engineers, whose President was unfortunately unable to be

present that evening, was of course the leading engineering Institution. When the Council of the Society of Engineers were called upon to decide a difficult point they would probably refer to the practice of the older Society. But sometimes it is the other way. Some of our senior Institutions might profit by the example of the younger ones ; for instance, they might well take a leaf from this Society's book by having ladies at their dinners. Dr. Kapp then went on to refer to the branch of engineering in which he was most interested, namely, electrical engineering, and dwelt on the part which electricity played nowadays in connection with railways, marine engineering and other specialised sections of engineering work.

Mr. Ernest George, A.R.A., President of the Royal Institute of British Architects, who also responded to the toast, laid stress upon the link which existed between engineering and architectural work, especially as regards the construction of buildings.

Mr. M. Holroyd Smith, M.I.E.E., proposed "The Ladies" in a humorous and entertaining speech. The toast was responded to on behalf of the ladies by **Mr. Percy Griffith, M.Inst.C.E.**, Past President of the Society of Engineers, who caused much amusement by the manner in which he outlined the influence of ladies upon engineering work.

The toast list being concluded, an adjournment was made to the Palm Court for a short time, the room in which the dinner had been held being in the meantime re-arranged by removing the large tables and substituting smaller ones more conducive to social intercourse. Coffee was then served, and an excellent programme of music was rendered under the management of Mr. Charles Capper. Mr. Capper himself was heartily encored for the excellent performance of a whistling solo, "Carmena."

This concluded the evening's entertainment, which was acknowledged on all hands to have been a most successful send-off for the new Society.

ELECTRICITY FROM THE WIND.

By ARTHUR H. ALLEN, A.M.I.E.E.

ALTHOUGH the windmill is one of the most ancient means of obtaining power from natural sources, and was very widely used in the Middle Ages, it has fallen into a very humble position in the scale of prime movers since the introduction of steam. But it would be quite a mistake to suppose that it is obsolescent. We hardly realise what we owe to the windmill, which, in company with the water-wheel, for centuries remained almost the sole example of the application of the inanimate forces of Nature to the service of man on land, and contained within it the germ of that modern miracle of engineering science—the steam turbine. Unfortunately, once it had attained to a moderate degree of development, it stopped there, and its design became to a great extent standardised. Windmills of the old-fashioned type are still at work in many parts of the country, and doubtless continue to do good service ; but who amongst us ever saw a new windmill of that description ?

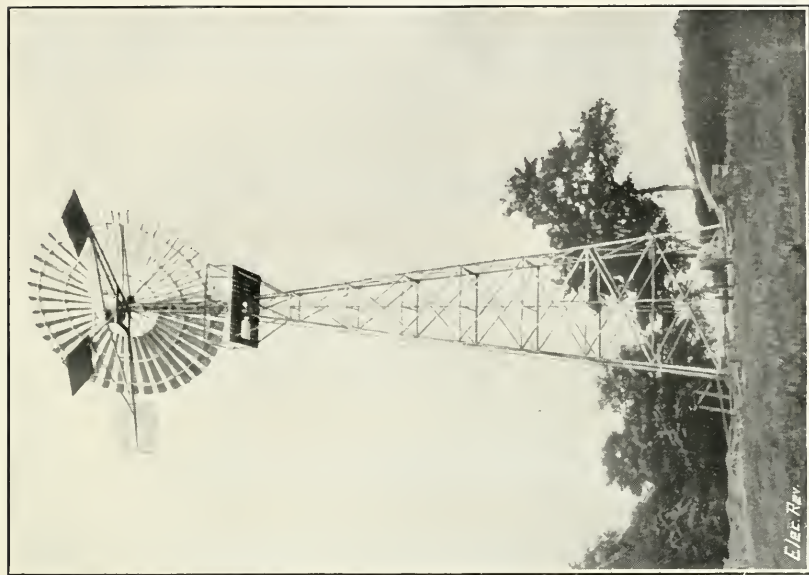
Modern methods and requirements have led to the evolution of a different type of wind motor, more closely resembling the water turbine, though not strictly included under the definition of a turbine, which has stationary guide blades as well as rotating vanes. In this form the wind motor has taken a new lease of life, and is capable of rendering valuable service to mankind. By far the most common application of the machine is to the pumping of water in country districts, for consumption, irrigation or drainage, one of the main reasons for this being the fact that the water need not be pumped continuously. It is here that we meet with the great drawback to the use of wind power—its variability from moment to moment, and even total cessation possibly for many days in succession. Water may be pumped into a reservoir for storage at any time when the wind supplies the necessary power, or allowed to accumulate in a low-level reservoir in the case of drainage when the wind does not serve, and thus the power of the wind may be utilised to the best advantage, in spite of its fickle nature. Storage, in fact, is the necessary condition which must be fulfilled if the inexhaustible store of energy placed at our disposal by the movement of the air is to be made conveniently available for practical application.

The facility with which water can be pumped at irregular periods and stored until required has led to proposals being made for its utilisation on a far grander scale than we are concerned with here. For example, in connection with the projected transmission of power from the Victoria Falls on the Zambesi River to the Rand, it was seriously suggested that when the

demand for power at the mines was low, the surplus power available could be used to store water locally at a considerable height, thus maintaining the load on the costly line at its full value; during the hours of heavy demand, the stored water would be employed to drive turbines in a generating station, and thus to aid the supply received from the Falls, besides providing a stand-by in the event of a breakdown on the line. That idea, however, like the proposed long-distance transmission, is dead and buried. The cost and inefficiency of the system, to say nothing of the excessively cumbrous nature of the high-level storage reservoirs, are fatal objections to its adoption. The only practicable means of storage is the electrical accumulator.

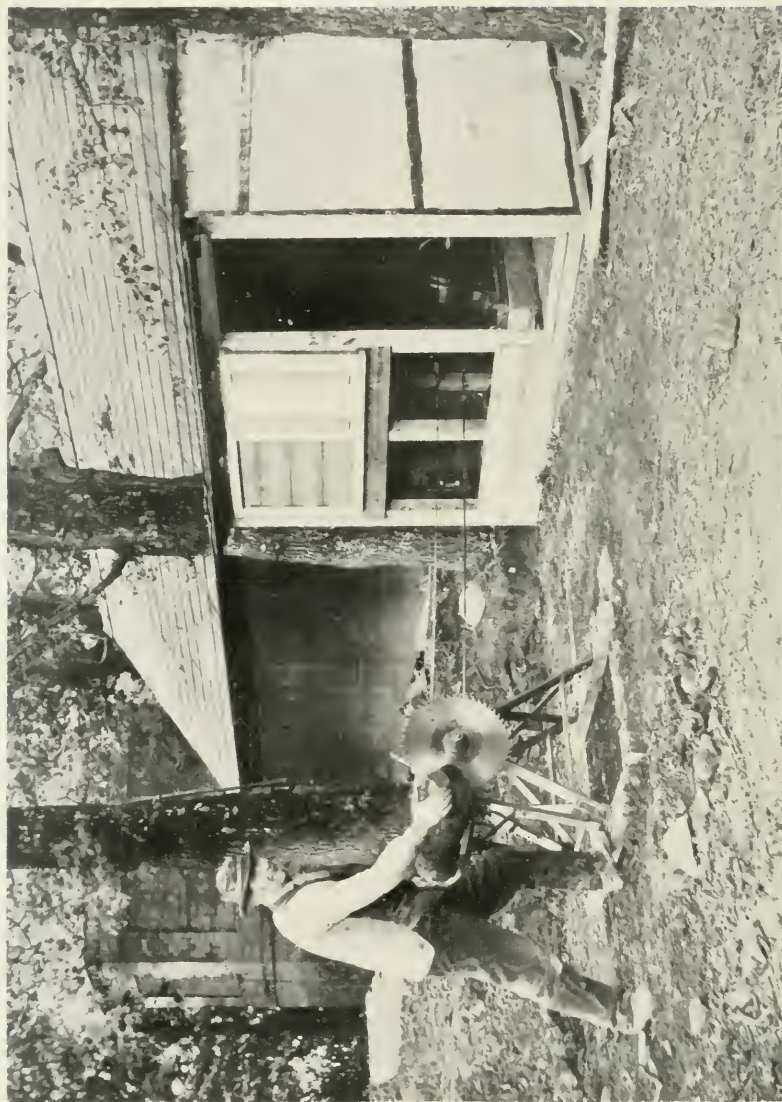
Fortunately, it happens that electrical storage is not only convenient and within the limits of commercial feasibility, but also stores the energy reclaimed from the air in a form ideally adapted for utilisation in a variety of ways. Lighting and power, heating and cooking—the principal requirements of modern civilisation after food and clothing, lodging, and water supply have been provided for—are the most obvious and readily accomplished functions of electrical energy; but there are also many minor applications of this versatile agent to which it is no less admirably adapted, such as charging the batteries of automobiles and portable lamps, etc. There are certain difficulties in the working of the system, due to the irregularity of the winds; but these are not insuperable, and there are numerous examples in existence of their successful solution, particularly on the Continent. In this country but little has so far been done towards developing the application of the system to supply the needs of isolated mansions, farms, etc., except in connection with water supply by wind-driven pumps, which are common enough; but a new factor has come into existence which may lead to the extensive adoption of electrical installations operated by wind power—namely, the metallic-filament lamp.

One of the principal objections to the use of the wind for lighting supply in the past has been the inefficiency of the lamps available, which not only necessitated the generation of a large amount of power, but also involved the provision of a large storage battery to tide over periods of calm weather, when the generating plant was inoperative. The new lamps, by cutting down both these items to one-third of their previous values, have completely changed the situation. For an installation of, say, 100 16-C.P. lamps burning simultaneously, which formerly required an output of 6 kilowatts, 2 kilowatts are now sufficient. Moreover, the small current consumption of the lamps enables a low voltage to be employed, without the necessity of using conductors of large cross-section, and this not only reduces fire-risk to the vanishing point, but also permits of a material economy in the cost of installation and maintenance of the



WIND TURBINE AT BUCKENHALL, BROMYARD.

Elle River



CIRCULAR SAW WORKED BY WIND POWER.

storage battery, which for a pressure of 25 volts consists of only 14 cells, as compared with the 55 formerly required for a 100-volt installation. The cost of the switch-gear and of the dynamo is also diminished owing to the low voltage, in addition to the reduction in their dimensions. The lamps themselves are less sensitive to variations in the pressure of supply than carbon-filament lamps, and for the low voltage mentioned they can be obtained of any candle-power down to 5 C.P., while the filaments are amply strong enough to withstand ordinary usage.

Thus the lighting problem has been greatly simplified, and with this important item out of the way the question whether it is feasible to make use of the electrical energy available in other directions assumes a different aspect. For domestic purposes, such as heating and cooking, electricity is admirably adapted, but the former, requiring a large output extending over long periods, can hardly be regarded as within the sphere of practice; cooking, however, can readily be performed, for though a considerable output is required at the commencement of the operation, a much smaller supply suffices to complete it, and the operation lasts only for a comparatively short time. With an available supply of two kilowatts the whole of the cooking for a family of six or eight persons can be done, with a degree of efficiency and convenience absolutely unknown to any other mode of cooking ever devised. There are also numerous other domestic applications of an electrical supply, such as ironing, sewing, knife-cleaning, etc., which consume very little energy in the aggregate, but represent a vast amount of comfort and convenience. In the farmyard chaff-cutters, circular saws, churns, separators and similar machines requiring but little power can be driven by electric motors, or by a single motor suitably mounted on a truck or belted to a countershaft. Other uses for the supply have already been mentioned, and as it is obvious that innumerable benefits are to be derived from the provision of an electric supply, we need not labour the point, but proceed to consider the requirements and conditions from an engineering point of view.

The fundamental principles underlying the utilisation of wind power are simple and few in number. The first consideration is of course the availability of the motive force; in this country the average velocity of the wind throughout the year is in the neighbourhood of $7\frac{1}{2}$ miles per hour, but for half the year it exceeds 10 miles per hour, which is well over the lowest speed at which a wind motor will work satisfactorily. For about one-third of the year the velocity approaches 15 miles per hour, and near the sea-coast, or in favourable situations inland, this may be much exceeded. The velocity of the wind is also higher in winter than in summer, a fortunate circumstance in connection with electric lighting.

The range of speed within which the plant should work is

from 6 to 25 miles per hour, though with suitable arrangements it is possible to work up to 35 m.p.h. The speed of the motor is approximately proportional to the velocity of the wind, and as the pressure of the latter varies as the square of the velocity, the output of the motor is theoretically proportional to the cube of the velocity of the wind; if a be the area of the vanes, in square feet, and v the velocity of the wind in miles per hour, the horsepower developed will be approximately given by the formula

$$\text{H.P.} = a \cdot v^3 + 150,000.$$

Thus a wind motor of 128 sq. ft. surface, with a wind of 9 miles per hour, gave an output of 0.625 H.P., while with a wind of $22\frac{1}{2}$ miles per hour it gave out about 10 H.P. These results were obtained by Prof. La Cour at Askow, in Denmark, with a four-armed wheel, the type which he recommends; the peripheral speed of such a wheel is about 2.5 times that of the wind. The more common type of wheel is that which has many vanes filling up about $2\frac{1}{3}$ times as much of the area of the circle swept out by the arms, and giving about as much power as the four-armed type of equal diameter, though running with a peripheral speed only about equal to that of the wind. The wind motor with many vanes runs more readily in light winds, and is therefore generally preferred to the four-armed type for the purpose here under consideration. The constant in the foregoing formula obviously must be greatly increased when dealing with the multiple-vaned type of motor, or so-called turbine; the power generated is approximately proportional to the area of the whole circle swept out, or to the square of the diameter of the wheel, but in practice the output of such a wheel is more nearly proportional to the velocity of the wind than to the cube of the velocity, and probably varies as some power of the velocity between 1 and 2. (See Appendix II.)

In order to provide against the varying force of the wind, which at high velocities may reach extreme and dangerous values, the wheel is usually equipped with an automatic system of control; either the vanes are automatically inclined more and more to the plane of the wheel as the pressure increases, against the controlling force of springs, or the wheel is bodily rotated so as to face more or less obliquely to the direction of the wind, thus reducing the resultant pressure upon the wheel. In the latter case the axis of the wheel is mounted somewhat to one side of the pivot upon which the head of the motor is supported, so that the pressure of the wind upon the wheel sets up a couple tending to rotate the carriage and throw the wheel "out of the wind," against the controlling force exerted by weighted levers or other suitable devices (Fig. 1). The speed of the wheel, however, is not kept even approximately constant by these means, which are rather intended to provide against excessive velocities. A rudder or tail attached to the carriage is usually employed to turn the

wheel to face the wind, except in the case of large motors, which are provided with a small auxiliary motor or wind-rose mounted on an arm at right angles to the plane of the wheel; whenever, therefore, the wheel is not face to wind, the small wheel must face it more or less, and being driven by the wind, actuates a rack and pinion gear, tending always to turn the main wheel into the wind and the small wheel edge to wind. The power developed is transmitted to the base of the tower by bevel gear or screw gear, and a vertical shaft; both this and the main shaft should be provided with ball or roller bearings, to reduce friction and avoid the necessity for frequent attention.

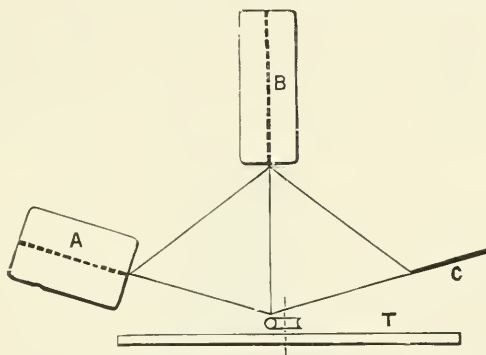


FIG. 1.—DIAGRAM OF CONTROLLING VANES.

The tower upon which the motor is mounted is usually constructed of steel angles, and should be at least 50 feet high, as the velocity and steadiness of the wind are materially reduced near the ground level.

At the base of the tower a horizontal shaft with bevel gear may be fitted, but a simpler and more efficient plan is that adopted by Messrs. J. G. Childs & Co., in which a flanged pulley is fixed on the lower end of the vertical shaft, and drives directly the pulley of a dynamo, likewise built with a vertical shaft running in ball bearings, and housed in a separate building close to the base of the tower. (See illustration opposite.)

The electrical equipment includes, besides the dynamo, a battery of accumulators—an indispensable feature—and an automatic switch, which cuts in the dynamo whenever the speed is high enough, and disconnects it when the speed falls to the point below which the dynamo is unable to charge the battery. Provision must also be made to prevent the dynamo voltage, and therefore the charging current, from attaining such a value as to injure either the machine or the cells; this may be effected by means of automatic switch-gear, but a much better method is to

make use of a dynamo specially designed for the purpose, in such a way that the current generated can never exceed a predetermined maximum. The problem is in many respects analogous to that of train-lighting by means of a dynamo driven from the axle of a coach, in conjunction with a storage battery. There is, however, a noteworthy difference between the two cases. In train-lighting, the driving force can be depended upon to be adequate to its purpose ; in obtaining power from the wind, one must make the most of one's opportunities, for no one can tell how long the breeze will endure. Instead, therefore, of aiming at a constant charging current as in train-lighting, irrespective of the speed at which the dynamo is driven, it is necessary to take advantage of the increased torque available as the breeze freshens, and to increase the charging current correspondingly. This object is attained in a high degree by the Leitner dynamo, the connections of which are illustrated diagrammatically herewith (Fig. 2). The peculiarity of this machine is

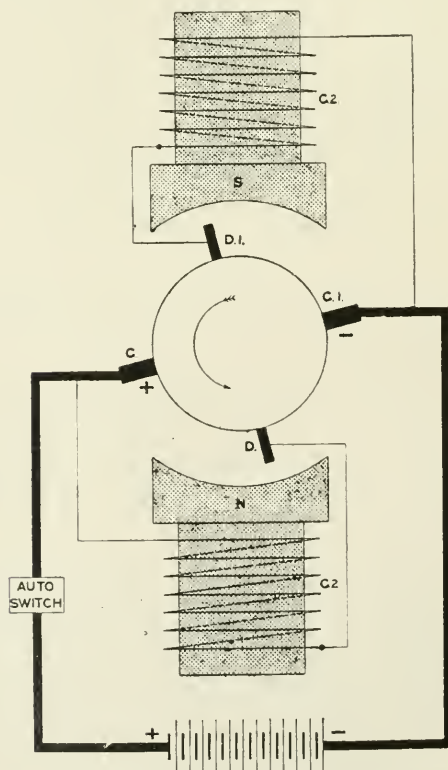


FIG. 2.—DIAGRAM OF CONNECTIONS OF DYNAMO.

that there is only a plain shunt winding on the field magnets, yet the characteristic is of the form shown in Fig. 3.

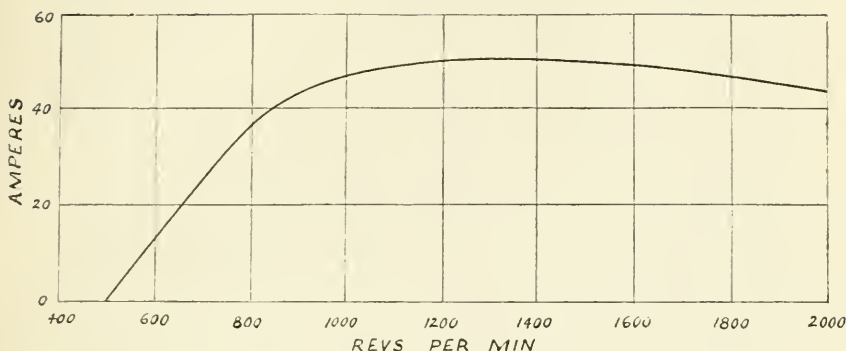


FIG. 3.—OUTPUT AND SPEED OF DYNAMO.

It will be seen that the current rises rapidly after a speed of 500 revs. per minute is attained, at which the voltage exceeds that of the battery and the automatic switch comes into action ; the current attains a maximum at about 1300 revs. per minute, and afterwards maintains a high value at speeds up to 2000 revs. per minute, these three speeds corresponding to wind velocities of 6, $15\frac{1}{2}$ and 24 miles per hour respectively. The curve must be regarded as typical only, for of course it can be modified to suit circumstances, while retaining the same general characteristics—for instance, the maximum current can be made to occur at higher or lower speeds, as desired. The object of causing the curve to flatten or turn downwards after attaining a maximum is to ensure that the mechanical stresses on the parts of the machine, and the rate at which the battery is charged, shall never exceed a fixed safety limit under any conditions.

The manner in which this result is attained is of considerable interest, as it affords a solution of a problem which has engaged the attention of electrical engineers for the past twenty years. As shown in the diagram, the shunt winding is divided into two equal sections (the illustration shows a two-pole machine for the sake of simplicity, but the dynamo is actually four-pole ; this does not affect the explanation in any way). Two auxiliary brushes are provided, situated on the commutator electrically at right angles to the main brushes, and therefore coming opposite the pole-pieces instead of between them, and a certain amount of lead, or displacement from the middle or neutral position in the direction in which the armature is running, is imparted to them. In consequence of this lead, when the armature is set in motion an electromotive force is generated in the windings between the

brushes D and C, and between brushes D1 and C1, causing a current to circulate in each half of the shunt winding, and exciting the field magnets. The original magnetism is, as usual, derived from the residual magnetism of the field-magnet cores, but may be supplemented if necessary by a weak excitation obtained from the storage battery. As soon as the voltage is sufficient to enable the dynamo to overcome the E.M.F. of the battery, the automatic switch closes the main circuit, and charging commences. At first, while the charging current is small, the effect of the auxiliary brush arrangement is to increase the excitation of the fields, but as the armature current increases, and reacts more and more upon the field magnets, the magnetic flux is displaced in the direction of rotation, and the effect of the auxiliary brushes diminishes to zero. As the speed of the armature, and consequently the current, continues to increase, the magnetic flux is further displaced, and its axis passes beyond the points where these brushes are applied; their effect then becomes reversed, and tends to reduce the magnetisation of the field magnets, not only preventing the current in the main circuit from increasing, but actually diminishing it, as shown. This result is attained with the minimum amount of winding upon the field magnets, and with an ordinary armature and commutator. All the brushes are mounted upon a common carrier, and are initially adjusted together, after which they need no further adjustment; and the cost of the machine is but little greater than that of an ordinary dynamo without such automatic regulation. Thus the effect of the wide variations in the velocity of the wind is overcome, so far as the dynamo is concerned, while advantage is taken of the increased torque available at the higher speeds.

The automatic switch to which reference has been made is a device which is well known to electrical engineers; its function is simply to disconnect the battery from the dynamo whenever the electromotive force of the latter is equal to or less than that of the former, and to establish the connection only when the E.M.F. of the dynamo is a few volts in excess of that of the battery. This is effected by means of a polarised armature, and a high-resistance winding connected in series with the dynamo and battery. When the former has the higher E.M.F., the polarised armature is tilted and closes a switch in the main circuit, at the same time cutting out the fine wire winding, and allowing the main current to flow through a heavy winding on the switch, which holds the latter in the closed position. Should the main current fall approximately to zero, the switch is opened by a spring or counterweight, and the fine winding comes into play again. As long as the battery E.M.F. exceeds that of the dynamo the effect of the current circulating through the fine winding is to hold the switch open. Should the dynamo break down while

charging the battery, the reverse current flowing through the thick wire winding would act on the polarised armature and throw the switch open ; but it is not advisable to rely upon the switch as a circuit-breaker in this way, and fuses should therefore be inserted in the circuit to prevent any possible damage due to an accident of this kind.

The remaining apparatus is such as is commonly installed in connection with a battery of accumulators for lighting supply ; on a small installation such as is here considered, a regulating switch would be provided, with which one cell could be cut out at a time, to a maximum of four cells, leaving ten in circuit when the battery was being charged and was approaching full charge, and adding cells one by one as required to maintain the voltage at other times.* This would be sufficient if charging were only done in the daytime, for the fluctuations of voltage due to the cutting in and out of the dynamo, as the wind rose and fell, would not then be felt. But if it were necessary or desirable to run the dynamo at night also, whilst the lamps were in use, an automatic regulator would be almost indispensable, to prevent continual and unbearable variations in the light. Such a regulator, for example, is employed in connection with the dynamo above described, for train-lighting. In the ordinary way, however, it could be dispensed with. For cooking, or driving small motors, the variations in the voltage would be of less importance ; and they could be minimised by a simple device actuated by the automatic switch, or by a separate solenoid in the charging circuit, which would cut out one or two cells from the supply circuit whenever the charging current attained a considerable value.

The size of the battery, as well as of the dynamo, must necessarily depend greatly upon local circumstances. It would be necessary to allow for a possible calm of 8 or 9 days as a maximum, but during a dead calm the owner would naturally take care that the battery was not unnecessarily drawn upon, and therefore it would not be essential to provide storage for the full average load during that period. As the strongest winds occur in winter, so do the fewest calms, and that is the time when the installation would be most needed. In the summer, when calm periods are more probable, but little lighting would be required, and less cooking than in winter ; and domestic operations entailing the consumption of electricity could be restricted to the minimum if a calm were anticipated. In some instances an oil or petrol engine has been installed in addition to the wind motor, to guard against any possible deficiency in wind power ; but in most cases this is quite unnecessary.

* It has been pointed out that a jump of one cell (two volts) has a considerable effect on 25-volt lamps. This might be mitigated by including a few accumulators of the Edison type (which have an E.M.F. of about 1.3 volts) for regulating purposes.

Where motors, etc., are to be installed as well as lamps, it is inadvisable to employ so low a pressure as 25 volts ; a more suitable value is 50 volts, at which pressure metallic-filament lamps of 8 c.p. can readily be obtained. Indeed, it is quite within the bounds of possibility that no long interval will elapse before these are available at 100 volts ; but on the other hand, by adopting the latter pressure—otherwise perfectly suitable for motors and other consuming apparatus—we should sacrifice the advantages previously cited as appertaining to a low pressure. In Appendix I. estimates are given of the cost of laying down and working such an installation, supplying about 100 16-C.P. (20-watt) lamps or their equivalent, cooking apparatus for 8 persons, and a few domestic motors, or perhaps electric heaters, irons, etc. The maximum possible demand of the installation would be in the neighbourhood of 6 kilowatts, but in practice this would never be approached, the actual maximum being probably not more than 3 or 4 kilowatts under any circumstances. The battery provided has a capacity of 480 ampere-hours, or 24 kilowatt-hours, and would be capable of supplying half the lamps for 24 hours—sufficient for more than a week's lighting in summer, without stinting the supply. During such an interval of calm weather, the motors would be used as little as possible, and cooking could be done with coal, which forms the cheapest stand-by for this purpose. The average amount of energy required for cooking purposes is about 0.7 kw.-hour per person per day, according to observations extending over long periods. The energy consumed by the motors necessarily cannot be more than guessed at, and would no doubt be regulated to some extent by the amount available. The consumption for lighting can be estimated by comparison with ordinary residence lighting, and a liberal allowance would be 10 kw.-hours per 20-watt lamp per annum. The estimates given, in the absence of detailed requirements and particulars of situation, etc., must necessarily be rough approximations, but are probably not far from the mark, and are justified by comparison with actual installations. It will be observed that the allowance for attendance on the wind power plant is put at a very low figure. This is based upon the well ascertained fact that a properly organised installation of the kind described needs hardly any attention at all ; the wind turbine requires inspection and oiling only at long intervals, and the allowance set down is really due almost wholly to the battery, each cell of which should be examined carefully at least once a week. Expert attention should rarely be called for. The oil engine, on the other hand, will require lubrication and attendance every time it is run, and needs cleaning and examination no less frequently. The turbine needs little in the way of repairs, and nothing very costly, whereas the engine is subject to many and various causes of trouble, and its mechanism is much more complicated and liable to injury than that of the turbine.

It will be seen that the cost of the energy consumed is about $4\frac{3}{4}$ d. per kilowatt-hour—a very reasonable figure, considering the small size of the installation and its probable position remote from any public supply system. No surprise will be felt, therefore, when it is stated that similar, but larger, installations have been working for some years on the Continent, not merely for lighting country houses and farms, but for supplying electricity to whole villages, with hundreds of lamps and many motors connected to the mains. There is no reason why such installations should not be carried out in this country; a few exist, but only for private use, and these have given complete satisfaction to their owners.

The cost of supply with oil engines is considerably greater, as shown below.

In putting forward this brief sketch of the subject, the author does not affect to have treated it other than superficially; but he trusts that in view of the scarcity of information on a matter so rarely brought before the notice of engineers, it may prove of sufficient interest to justify its presentation to the Society. His thanks are due to the firms named in the text for the loan of blocks and photographs used to illustrate this article.

APPENDIX I.

Initial and running cost of a Wind-Power Installation supplying electricity to 100 16-c.p. 20-watt tungsten lamps at 50 volts, together with a few motors, cooking apparatus, etc.

<i>Capital Cost</i> :—	£
24-ft. Wind Turbine and 60-ft. tower	250
Special Dynamo, giving 50 amps. at 50-70 volts ..	40
Switchboard	30
Battery of 27 cells, of 480 amp.-hours capacity, with wooden stand, etc.	100
Dynamo and Battery House	30

Total £450

<i>Running Cost</i> :—	£
Attendance on battery and generating plant ..	10
Repairs, oil, etc.	10
Interest on Capital at 4 per cent.	18
Depreciation on battery at 15 per cent.	15
Depreciation on rest of plant at $7\frac{1}{2}$ per cent. ..	26

Total per annum £79

Energy used for lighting, say	1,000 units
„ „ „ cooking (8 persons)	2,000 units
„ „ „ motive power, say	1,000 units

Total 4,000 units
at $4\frac{3}{4}$ d. per unit.

Capital Cost of Plant with Oil Engine instead of Wind Turbine :—

	£
Oil Engine and Accessories	120
Rest of Plant as before	210

Total £330

Running Cost, with Oil Engine :—

	£
Attendance on Engine and Battery	26
Repairs, lubricating oil, etc.	20
Fuel oil, at 1 $\frac{1}{4}$ d. per unit	21
Interest on Capital	13
Depreciation on Battery at 15 per cent.	15
Depreciation on rest of plant at 7 $\frac{1}{2}$ per cent.	17

Total £112

Increased cost as compared with Wind-Power Plant, 42 per cent. Cost per unit, 6 $\frac{3}{4}$ d.

APPENDIX II.

The following data, supplied by Mr. J. Wallis Titt, of Warminster, who has had a very extended experience in the manufacture of wind turbines, will be of interest. Wheels from 10 to 16 feet in diameter are made of steel, and governed with a hinged tail vane ; larger sizes are made with canvas sails, and governed with a weighted lever, the leverage of which can be altered at any time to suit the work to be done and the varying velocities of the wind. The smaller sizes are of little use for generating electricity, and are therefore omitted from the table. It will be noticed that the speed varies inversely as the diameter, the horse-power directly as the square of the diameter, and the horse-power and speed directly as the velocity of the wind. The figures are obviously approximations only, based upon these ratios :—

DIAMETER OF WHEEL.	REVS. PER MINUTE.		NET EFFECTIVE HORSE POWER.	
	Wind 10 m.p.h.	Wind 15 m.p.h.	Wind 10 m.p.h.	Wind 15 m.p.h.
20 feet ..	17.6	26.3	0.57	0.86
25 „ ..	14.0	21.0	0.89	1.34
30 „ ..	11.8	17.6	1.29	1.93
35 „ ..	10.0	15.0	1.75	2.62
40 „ ..	8.8	13.25	2.28	3.43
45 „ ..	7.8	11.7	2.84	4.27
50 „ ..	7.0	10.5	3.65	5.48

CORRESPONDENCE

ON

“ELECTRICITY FROM THE WIND.”

Mr. Henry C. Adams, A.M.Inst.C.E., referring to Mr. Arthur H. Allen's paper published in last month's Journal, writes:—

May I ask Mr. A. H. Allen to explain the formula given on page 10 for ascertaining the horse-power of a windmill. It would appear from the experiments of Professor La Cour that the formula should be written $a.v^3 \div 150,000$ where v = velocity of wind in miles per hour.

The formula given by Molesworth is $0.00000091 a.v^3$ where v = velocity of wind in feet per second. If, however, the velocity is taken in miles per hour, the formula becomes $0.00000287 a.v^3$

or $\frac{a.v^3}{348,432}$ say approximately $a.v^3 \div 350,000$ which will give a very different result to Mr. Allen's formula.

The statement in Appendix II. that “the horse-power (varies) . . . directly as the velocity of the wind,” together with the figures in the subsequent table based upon such ratio, does not appear to agree with the statement on page 10 that “the output of the motor is theoretically proportional to the cube of the velocity of the wind.”

In reply, Mr. Allen has furnished the following notes:—

Replying to Mr. Henry C. Adams's queries regarding my article, there is an obvious misprint in the formula, which should of course read $a.v^3 \div 150,000$. I agree with Mr. Adams's figures for Molesworth's formula, and Weisbach gives a formula nearly identical in value with Molesworth. The reason why Professor La Cour obtained a value for the power more than twice as great is probably the fact that he had been investigating the best form, number of sails, speed, etc., for the wind motor, and thus was running the latter under the best conditions attainable; he gives a particular “conical” shape to the sails, for which he claims a far greater efficiency than can be obtained with the usual pattern of sail, such as, no doubt, the earlier values were based upon. Mr. Adams will find on page 10 that I point out that the ordinary type of wheel, with many vanes, has about $2\frac{1}{2}$ times the sail area for the same diameter as Professor La Cour's type, but only gives about the same power; this statement agrees pretty closely with Mr. Adams's comment, and I also point out that the constant must be greatly increased when dealing with the “turbine.” Unfortunately the data that I was able to obtain were not sufficiently

concordant to permit me to commit myself to a definite formula, though I made many inquiries and calculations from (alleged) measured results. The replies I got from actual makers were such as the following :—" Only wish we could give you some reliable figures on the subject. Unfortunately, however, we have no figures at all in connection with electric supply which would be of any use to you, as our wind machinery is nearly always adapted to raising water only." Apparently an exact knowledge of what his machines could do was not necessary to this maker's business. Again :—" We have not been able to make a full experimental investigation into the exact power which is obtained in practice . . . we do not think a definite law can be given."

As regards the statement in the Appendix that the horse-power varies directly as the velocity of the wind, this is in substantial agreement with the statement on page 10, line 28 :—" In practice the output of such a wheel is more nearly proportional to the velocity of the wind than to the cube of the velocity, and probably varies as some power of the velocity between 1 and 2." As I point out in the Appendix, Mr. Titt's figures are obviously approximations only—they follow the proportion too closely to be experimental results. As a matter of fact, the powers given by Mr. Titt appear to me to be much too low ; in the " Electrical Review " of October 19th, 1906, p. 649, one of his windmills is stated to have, *according to the maker's tables*, an output of three horse-power with a wind of 10 miles per hour, the wheel being 30 feet in diameter ; in the table sent to me, the H.P. is said to be only 1.29. The output of the motor is *theoretically* proportional to the cube of the velocity of the wind, but when the wheel is provided with governing devices to turn it out of the wind, or to furl the sails, and is not run at the particular speed which gives the greatest output corresponding to a given velocity of wind, the conditions for obtaining the theoretically obtainable result are not fulfilled. Professor La Cour certainly accomplished this, but no practical data that I have ever seen, except his, even remotely approach proportionality to the cube of the velocity. A thorough experimental investigation of the whole subject is badly needed.

7th February, 1910.

FIRST ORDINARY MEETING OF THE NEW SOCIETY.

THE first Ordinary Meeting of the new Society was presided over at its commencement by Mr. E. J. SILCOCK, M.Inst.C.E., F.S.I., F.G.S., last President of the Society of Engineers, and by Mr. W. NOBLE TWELVETREES, M.I.Mech.E., A.M.I.E.E., last President of the Civil and Mechanical Engineers' Society. The minutes of the last Ordinary Meetings of the Society of Engineers and of the Civil and Mechanical Engineers' Society were read, confirmed and signed.

PRESENTATION OF PREMIUMS.

Mr. E. J. Silcock : Gentlemen, unfortunately all three of the recipients of the Society's premiums are unable to be present this evening. The President's Gold Medal has been awarded to Dr. Somerville for his paper, entitled, "Some Observations on the Chemistry and Bacteriology of Sewage Purification." The Nursey premium, value three guineas, which takes the form of books, has been awarded to Mr. E. R. Matthews for his paper on "The Corrosion of Steel Reinforcement in Concrete." A Society's premium of books, value £2 2s., has been awarded to Mr. W. E. Haldwell for his paper on "The Sinlumkaba Ferro-Concrete Bridge." That paper gave a description of a ferro-concrete bridge constructed in India, and the author is in India at the present time.

I will now ask Mr. Twelvetrees to present the premiums awarded by the Civil and Mechanical Engineers' Society.

Mr. W. Noble Twelvetrees : Mr. President and gentlemen, it is a very great pleasure to me to perform the function which the Chairman has just announced to you. Two premiums awarded by the Civil and Mechanical Engineers' Society for papers read during the Jubilee Session are to be presented this evening, one to Mr. R. O. Wynne-Roberts for his very interesting and suggestive paper on "The Past, Present, and Future of the Organisation of the Engineering Profession." We have just been engaged in helping in some measure to organise the engineering profession by amalgamating two societies, which, if not the largest in the profession, are at any rate among the oldest.

The second premium is one presented to Mr. H. Laurence Butler for his useful and instructive paper, entitled "Specifications for Engineering Works." I heard that paper read with a good deal of pleasure.

The presentations were then made, and suitably acknowledged.

Mr. E. J. Silcock : Gentlemen, it is now my pleasing duty to express the thanks of the Society of Engineers to the other authors who read papers during the past Session. I am sure that all the papers are worthy of prizes, and the Council had great difficulty in determining which were the most valuable, and, unfortunately, we have not sufficient premiums to award prizes to all. The papers read were as follows :—

“ A New Test for Concrete.” By J. S. Owens, B.A., M.D.

“ The Influence of Rainfall on the Design of Sewers.” By C. A. Battiscombe.

“ Steam Wagons.” By J. C. Cornock, A.M.I.C.E.

“ The Mechanics of Dust.” By C. H. W. Biggs.

The Status Prize has already been presented to Mr. G. Allan Thomas for his essay on “ The Status of the Engineering Profession.”

Mr. W. N. Twelvetrees : For the same reason that Mr Silcock has just mentioned, The Civil and Mechanical Engineers' Society were not able to award premiums to all those who read papers before the Society last Session. I wish to offer the thanks of the Society to the following authors of papers :—

To Capt. W. G. Windham for his paper on “ Balloons and Aeroplanes.”

To Mr. J. Sutherland Warner, A.M.I.Mech.E., for his paper on “ The Influence of Track upon Railway and Tramway Carriages.”

To Professor Henry Adams, M.Inst.C.E., M.I.Mech.E., for his paper on “ The Stability of Arches.”

To Mr. R. Borlase Matthews, A.M.Inst.C.E., for his paper on “ Some Commercial Aspects of Central Electricity Supply Station Management.”

To Dr. J. S. Owens, A.M.Inst.C.E., for his paper on “ Storms and their Effect on the Sea Coast.”

Mr. A. S. E. Ackermann, B.Sc. (Engineering), for his paper on “ Technical Popular Fallacies.”

INDUCTION OF THE PRESIDENT.

Mr. Silcock : Gentlemen, I have now the privilege of introducing to you Mr. Diogo A. Symons, who has been chosen as the first President of the new Society. (To Mr. Symons) I have to congratulate you, Sir, on your appointment and to invest you with the badge of office.

Mr. Percy Griffith : Mr. President, the honour of being called upon as the first speaker on your assumption of the distinguished position of President of the new Society is one which I feel very deeply indeed. The purpose for which I am speaking is to direct your attention to a gentleman who represents to us the past.

Our new President represents to us both the present and the future. But this Society would not have either present or future if it were not for its very honourable past. I ask you to express your appreciation of the work which the President who has just vacated the Chair has done during the past year. Mr. Silcock is well known to every one in this room, whether or no he has shaken hands with him or received his personal greeting. We have been fortunate in having been able to select as our President during last year a gentleman who has obtained considerable prominence in the profession of consulting engineer. I will not dilate upon his previous experience as a municipal engineer, because that would take too much time, but I do think that we owe to our immediate past President a little more thanks than are usually due to the gentlemen who have occupied the position of President. Under his Presidency the most important and historic event which either of the two societies has experienced in the course of their long careers has been carried through, namely, their amalgamation, now so happily consummated. I am speaking as one who knows how the details and internal working of that important change have been carried out, and I am betraying no secret in informing you that they have been carried out without a thought, much less a word, of friction, jealousy or anything allied to hostility. It has been due to the discretion and wise supervision and guidance of our President that all possible difficulties (and they have been great) have been removed without any trouble. The amalgamation having been completed so amicably, I think that our past President may safely rely upon the members to follow up the work which, under his guidance, has been so thoroughly well initiated, and to carry it to that successful conclusion which it is the hope of every member of the two Societies may be accomplished. I wish to point out to you that, however hard the new Council may work in the interests of the new Society, without the cordial, active, and constant support of every member, their work will be, relatively speaking, ineffective. I think that I may, in the name of our past President, appeal to the members of this new and large Society to carry on the good work. I could speak at great length with regard to our past President, but fortunately I can rely upon the knowledge which all present have of his work and of himself, as sufficient to secure a very cordial reception to the vote of thanks which, in your name, I offer to him. From the bottom of my heart I move "That the most hearty thanks be accorded to Mr. Silcock for his services in the Chair of the Society of Engineers during the past year."

Mr. A. G. Drury, in seconding, said that he cordially endorsed all that Mr. Griffith had said. No further words were needed to commend the vote.

The vote of thanks was carried with acclamation.

Mr. E. J. Silcock : Mr. President, Mr. Griffith, Mr. Drury, and gentlemen, I am exceedingly grateful for the kind way in which this vote of thanks has been proposed and received. My duties as President of this Society have been a very great pleasure to me and my year of office has been one of unbroken harmony between myself and the members of the Council and the members of the Society generally. I have received the greatest kindness and support from all the members of the Council. I have especially to thank our new President for taking up the duties when I unfortunately had to be absent. Sometimes attending meetings of the Society involves me in a journey of nearly four hundred miles. I have been able, I think, to attend all the ordinary meetings and most of the visits, but at some of the Council meetings and the Committee meetings I have found it quite impossible to be present, and Mr. Symons has very kindly stepped into the breach on those occasions. Mr. Griffith was good enough to suggest that I had had a large share in the proceedings with regard to the amalgamation. I am afraid that I cannot lay claim to this, but so far as it has fallen to me to assist in the amalgamation it has been a work which I have done with very great pleasure and I am exceedingly gratified that it has been brought to a successful issue.

In conclusion I wish to record my hearty thanks to Mr. Ackermann, our worthy secretary, for the kind way in which he has supported me and the great care which he has taken in preparing everything for the meetings in order to lighten my labours as far as possible.

Mr. E. H. G. Brewster : Gentlemen, it has fallen to my lot to have the pleasure, and, I might also say, the sorrow, of proposing a hearty vote of thanks to our late President Mr. W. Noble Twelvetrees. It is a sorrow in that it means a breaking with the past. I joined the Society in 1872 and was its President in 1886. I have been its honorary treasurer and honorary secretary. I was, and am, pleased that I had the opportunity of seconding the formal resolution, at the Council Meeting held on January 9th, 1908, for the amalgamation of the Civil and Mechanical Engineers' Society with the Society of Engineers, because I saw that it would be good, not only for both Societies, but for the profession as a whole, in that we were amalgamating two old engineering societies and forming them into one strong body.

Mr. Twelvetrees has been a member of the Civil and Mechanical Engineers' Society for over twelve years, and has contributed many admirable papers. I sincerely hope that he will render the new society equally good service. It is with great pleasure that I propose this vote of thanks.

Mr. Walrond : Mr. President and gentlemen, I have very much pleasure in seconding this vote of thanks. Mr. Twelvetrees

has been President of the Civil and Mechanical Engineers' Society for two and a half years and during this time he has done a great deal of work in connection with it, not only as President, but also as a member of the Joint Committee of Amalgamation, and in revising the proposed By-laws and Articles of Association of the new Society.

The vote of thanks was carried by acclamation.

Mr. W. Noble Twelvetrees : Mr. President, Mr. Brewster, Mr. Walrond, and gentlemen, I am very much indebted to you all, but I feel that some of you are taking me rather on trust. I refer more particularly to the members of the Society of Engineers who do not know anything about me. You do not know whether I have done my duty well or badly. But you believe the gentlemen, my very old friends, who have told you that I have done something, and I suppose that you believe them more than I do myself. I have not had the pleasure of belonging to the Civil and Mechanical Engineers' Society for so long as my friend Mr. Brewster, whose membership extends over something like thirty-eight years. I have only been a member for about twelve years. I have found the proceedings of the Society useful to me. We have been favoured with excellent and well thought out papers. The discussions have been interesting and I have met many pleasant acquaintances who have developed into old friends. I am sure that the same sort of thing has occurred in the Society of Engineers. The two societies started at very nearly the same time, and each has been going along in a separate rut. At last they have come together and I wish to say to the members of the Society of Engineers that all the members of my old society look forward to the amalgamation of the two societies as a union that will prove of immense benefit to us all and, I hope, to the profession at large.

The **President** then delivered the following Inaugural Address :—

GENTLEMEN,

In addressing you as your President for the coming year, I feel it my first duty to thank you sincerely for the honour which you have conferred upon me by electing me to this high position, the responsibilities of which I keenly feel, following as I do the eminent members of our profession who have in bygone years occupied the chair of the two Societies. I especially feel the responsibility of the office which I now hold, in view of the fact that this is the first year of the amalgamation of the Society of Engineers with the Civil and Mechanical Engineers' Society, and consequently the honour of first addressing the united body on being elected to the chair falls upon me.

I cannot help expressing the opinion that the presidential duties could readily have been placed in far more capable and

experienced hands than mine. However, I will do my utmost for the new Society and its interests, and hope that with the co-operation which you have been good enough to give to my predecessors in both Societies and which I feel sure you will extend to myself, the coming year will be in every way a successful and satisfactory one.

The year just closed has been a very important one in many respects. I allude more particularly to the amalgamation which has recently taken place, and to which I have already referred, an amalgamation the possibilities and prospects of which will, I am confident, appeal to everyone who has at heart the interests of the two Societies concerned. "Unity is strength" is an old-world saying, but it is nevertheless, to my way of thinking, an expression which is especially applicable in many ways to engineering and other professional societies, and combination is, I think you will all agree, most conducive to the general development of our own particular profession.

MEMBERSHIP.—I understand the joint membership of the constituent Societies is over 700. With this number of members it should not in my opinion be necessary for me to reiterate the strong remarks which many of my predecessors in both Societies have found it necessary to make with a view to emphasizing the great importance of an abundant supply of papers to be read and discussed at the Society's meetings, and further with a view to urging upon the members the importance of good attendance at such meetings. It is my desire, however, to say that the success of a Society such as ours is greatly dependent upon the attendances at the meetings, and on the interest taken in its proceedings by the members themselves, and therefore, more especially as some very interesting and instructive papers will be read during the coming session, I sincerely hope that members will show their appreciation by doing their utmost to attend the meetings, and lend their aid by joining in the discussion.

EXAMINATIONS.—Another matter of considerable and far-reaching importance which has been introduced in connection with the amalgamation is the question of instituting a form of entrance to Fellowship of the Society—that is to say, entrance by means of examination.

You are all doubtless aware of the method in which these examinations will be dealt with, and it would therefore appear to be unnecessary for me to devote any time or space at the moment to this question, but I should in passing like to express my complete concurrence in the proposed methods of entrance to the highest rank of membership—methods which have been in force in connection with our premier Institution and near neighbour, the Institution of Civil Engineers, with eminently satisfactory

results for the past eleven years,—and I feel sure in my own mind that the practice referred to would be the means of improving the status of the new Society and would be attended with the same successful results as in the case of the senior Institution.

Now, gentlemen, I will not weary you with a long reference to matters concerning the working of the two old Societies, because you are all aware or should be aware of all that has occurred in connection therewith during the past year, and also of those questions concerning the welfare of the new Society which have been and are now occupying the minds of those gentlemen constituting its Council and Officers. In accordance with the usual custom, therefore, I will proceed to illustrate to you as clearly as the limited time at my disposal will permit, some of my own personal experiences in this far-reaching and ever-spreading profession of ours, in the hope that they may contain at least some proportion of interesting matter, but before concluding my address I propose again referring to the amalgamation.

My experience has been a varied one, embracing Harbour and Railway construction, Sewerage, Sewage Disposal and Water Supply, and in the following remarks I will endeavour to touch lightly upon some of these subjects.

WORKSHOP PRACTICE.—Before proceeding further I should much like to call the attention of those who perhaps are considering an engineering career for their sons or others, to the immeasurable and lasting benefit to be derived from a course of instruction in the “shops.” Whether it is intended to take up civil or mechanical engineering as a profession, it is in my opinion almost a necessity that the student should acquire that practical knowledge which is only obtainable in the workshops, and though perhaps this training is more obviously necessary to the mechanical branch of engineering, still it cannot be gainsaid that his brother of the civil branch is often called upon to provide solutions of mechanical problems, and it is in dealing with such problems that a knowledge of the shops will prove, and has proved invaluable to the civil engineer. I belong to or am a member of the civil branch, and I have often looked back with gratitude to the time I spent in the shops of a millwright.

FOREIGN WATER SUPPLY.—During the last few years I have been associated with works of water supply and sewerage, with which the name of Mr. Silcock, the last President of one of the constituent Societies, is so eminently connected, and of which he so ably and clearly treated in his Inaugural Address that I am somewhat diffident in addressing you upon these subjects. I will, however, with your permission, refer to one or two schemes with the design of which I was associated.

As a first instance I would mention an extensive scheme of water supply for a large city in Eastern Europe, the water for which, it was ascertained, would have to be conveyed from a source over eighty miles distant, this being the nearest spot from whence a supply sufficient in quantity and efficient in quality could be obtained. After a full and careful investigation on the ground, involving the expenditure of a great deal of time and money, it was found that the water could be brought to the city by gravitation, and it then became necessary to fix upon the cheapest and at the same time most reliable method of constructing the main conduit from the head works to the locality to be supplied. As a result of most careful consideration and exhaustive enquiries, it was ultimately decided that Lock Bar steel pipes should be adopted—firstly, on account of the great saving thereby effected in weight as compared with cast iron; secondly—on account of the higher tensile qualities of this form of conduit; and thirdly—on account of the practical form of construction of the pipes themselves, coupled with the fact that the convenience of shipment was far superior to other pipes or tubes of similar dimensions. It will doubtless be remembered that this description of steel pipe was adopted in the construction of the Coolgardie Waterworks, Australia.

The pipes in the instance under review varied in diameter from 31in. to 18in., and it is interesting to note that the greatest pressure falling on the 31in. pipe was 366 lb. per square inch with the water flowing. The stress imposed upon the pipe material was 6.75 tons per square inch, and it will easily be realised that although the stress could by no means be considered small, yet with steel of approved quality a sufficient factor of safety had been allowed for.

The service reservoirs—three in number—were situated at different levels, and naturally in the most advantageous positions, and it was calculated that the most economical and satisfactory method of working the reservoirs was first to charge the intermediate reservoir, from whence the water would flow by gravitation to the low-level reservoir, the high-level reservoir being served by means of suitable machinery operated by the flow of the water from the intermediate to the low level. It was confidently anticipated by those responsible for the design of the scheme that this method of distribution would prove far more efficacious than gravitating the water from the head works direct to the high-level reservoir. The difference of level between the intermediate and high-level reservoirs was about 170ft., and it will be easily realised what a large increase of pressure would have been imposed on the main by gravitating direct to the high level, owing to the increased height of the hydraulic mean gradient.

There were numerous other details in connection with the design of this scheme which would doubtless prove most interest-

ing to you, but which the time at my disposal precludes from being mentioned here.

The great importance of giving due and careful consideration to future requirements was much emphasized in the case of the water supply of one of the best known foreign seaside resorts upon the inefficiency of which it was my privilege to advise. This instance was remarkable from the fact that although the headworks were of excellent design, and the quantity of water (which is obtained from the chalk formation) was ample for many years to come and thoroughly efficient in quality, the system itself was designed and constructed without any regard whatever to the future requirements of the town, and, moreover, absolutely no accommodation for the storage of water for use in cases of emergency was provided. A further remarkable fact was that the service reservoirs were situated in such positions that in many instances the pressure was insufficient to force the water above the second floor of the important buildings in the town. Fortunately, the supply, as I have already mentioned, is ample, but it is not difficult to realise what disastrous results would without doubt be occasioned in the event of accident or damage to the main supply conduit to the reservoirs. I think I may be allowed to mention that the scheme was not designed by an English engineer.

It was found necessary entirely to re-design the whole scheme, involving the expenditure of several thousands of pounds, in order to make the supply efficient.

FERRO-CONCRETE.—As you are all aware, ferro-concrete has in recent years been extensively used in works construction, and there is no doubt that in many instances it is found to be very useful and economical, but for my own part I cannot help thinking that where complicated stresses are present it renders it an open question whether reinforced concrete is the most efficient form of structure to be adopted. It must in all cases be remembered that the internal stresses which are continually taking place are acting on material which is not visible, and consequently it is impossible to ascertain to what extent, if any, deterioration has been or is in progress.

To give an instance, the necessary calculations are practically based on the ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete. From the calculated section is obtained the moment of inertia of the whole, this value being obtained by the general methods and proportional to the square of the distance of the various areas of section from the neutral axis. Should the distance of the reinforcements from some cause or other vary from their original position, the moment of inertia will be altered, and as a consequence the moment of resistance of the section will have a different value.

From these few remarks it will, I trust, be understood that it is not my object in any way to find fault with this form of construction, as it is so largely used at the present time, and has been proved in so many instances to be in every degree excellent and satisfactory; but I certainly consider that in many forms of design a very large factor of safety should be taken, and that every effort should be made to ensure the use of the very best and most efficient materials in the construction of this class of work.

SEWAGE DISPOSAL.—The question of the disposal of sewage is one which has held the first place in the attention of engineers who specialise in sewerage and sewage disposal for many years, and developments in various systems or methods of treatment—good, bad, and indifferent—are taking place almost every day, but notwithstanding these innumerable developments there is still a tremendous field open for still further improvement in the methods adopted, and no engineer or chemist will, I feel sure, dispute the fact that the problem of satisfactory and innocuous disposal of sewage and waste liquids is still some long distance from solution. It is, however, most gratifying to note the great and lasting improvements which after lengthy and exhaustive investigation and experiment have been brought out during the past few years.

My late firm were associated with this branch for many years and designed and superintended the construction of numerous works all over the country on the upward filtration, roughing filter, and contact bed principle, followed by land treatment, and in all these instances the effluent was of a most satisfactory and innocuous character, and in addition the works themselves gave no cause for complaint as to easy and efficacious operation. From current reports, however, we are informed that this system is now considered to be almost obsolete, and is being superseded by superior methods. Upward filtration is now described as being wrong in principle, whilst percolating filters have, in a great number of instances, taken the place of contact beds.

So, gentlemen, this deep and at the same time interesting problem goes on from day to day, and presumably before the world is very much older some scheme quite new will be brought before the public as “the only certain cure for all sewage disposal troubles.” Many and various patent systems have been boomed from time to time and have for a time enjoyed a certain amount of prosperity, but most of them have now disappeared, to the joy of the civil engineer and in numerous cases to the chagrin of the shareholder.

Probably at some not very distant date a standard method of disposal, being both efficient and inexpensive, will be brought into operation so that practically speaking the same description of disposal works will be adopted in all cases, with certain

necessary eliminations or additions, as the case may be, in order to render such works suitable for the varying requirements of the locality to be dealt with.

The voluminous Report of the Royal Commission gives a remarkable illustration of the vast amount of time and energy which has been and is still being expended upon this seemingly unfathomable subject.

In questions of sewage disposal the opinion of the chemist has oft-times proved invaluable, a fact which has been recognised to a very large degree in recent years, and I cannot help thinking that in many instances it would go far towards the solution of the problem at issue if the engineer and chemist were to co-operate more than is at present the case, the works themselves being designed according to well known fundamental principles by the engineer, and the particular form of disposal to be the result of unbiased investigation and conclusions on either side. These two professions have always been friendly disposed towards one another, and there does not appear to me to be any reason why something in the nature of what I have proposed should not be carried into effect.

I would here mention that I have been much impressed with the working of the hydrolitic tank, the results obtained appearing to be very satisfactory and well worthy of serious consideration.

QUANTITY OF WATER PER HEAD OF POPULATION.—Before leaving the kindred subjects of water supply, sewerage and sewage disposal, I should like to say a few words with regard to the quantity of water required per head of population in foreign towns, and more particularly in the tropics. From my own experience this allowance is not more than in our own country, and at first glance it strikes one as being most extraordinary that in a tropical country like South America, in towns with a population of say 40,000, the same quantity per head per day as is used in this country should be sufficient, but it must be remembered that in these particular places, although the better class people use more than those in temperate zones, the lower class element has all its requirements satisfied with an allowance of about ten gallons per head per day.

I would here testify to the satisfactory relations I have invariably had with the inhabitants of foreign countries in connection with engineering and other business. I am bound to say that I have always found them courteous and most anxious to assist Englishmen in every way that lies in their power. In fact I cannot be accused of exaggeration when I say that it is my opinion that in cases where trouble and unpleasantness has arisen it has been largely due to our own countrymen. Englishmen who go abroad appear to be impressed with the idea that so long as they conduct themselves and transact their business as

if they were at home all is well. My experience is that such is not the case. Every country has its customs and "tricks" of etiquette, and the customs of the country in which we are working must be conformed to, and if this is carried out, and a little more "give" and less "take" is practised, it may be taken for granted that matters will be found to run much more smoothly for both parties concerned.

Whilst on the subject of engineering work in other countries I cannot help calling attention to the great number of English companies which have been and are still being placed upon the market for the purpose of providing the necessary capital for carrying out projects—many of which are of considerable magnitude—of all descriptions, but chiefly railways, in various parts of the world. The shares of such companies are in most instances liberally subscribed for by British investors, and as a consequence a vast amount of British capital is invested in foreign projects. A great deal has been recently written with reference to capital going abroad, but it should not be overlooked that, particularly in engineering enterprise in a foreign country, the works carried out by means of, or with the aid of British capital are invariably designed by British engineers and carried out by British contractors, so that a proportion of the capital does not leave this country and a great deal of the emigrating capital is often returned from whence it came.

GOVERNMENT GUARANTEES.—In connection with the financial side of many of these schemes abroad inducement is often offered to investors by the putting forward of the fact that Government or State guarantees are given. "Government Guarantees" sounds well, and looks well in print, but it should not be overlooked that in many instances they can by no means be considered a gilt-edged security. Moreover, in many cases it is specifically stated that the guarantee will not be exceeded. In other words if the undertaking should not prove to be a profit-making concern, and shows a loss on its operations, any deficiency to the bond or guarantee holders which is thus occasioned is not made up under the guarantee, consequently a portion of the guaranteed interest would be required to make up this deficiency. From these remarks it will be readily appreciated how important it is before embarking one's money in enterprises of this description to ascertain as far as possible the earning capacity of the venture in which it is proposed to invest.

Guarantees such as those to which I have referred are practically invariably paid in the currency of the country and it is this fact which in a great number of instances hampers enterprise. If this drawback could by some means or other be made clear to those in authority in foreign countries, with the result that interest would be paid in the English gold currency, I feel confident that

many of the undertakings and negotiations which so often prove abortive under the present method of procedure would mature with resultant good business.

Only within the last few months it was my privilege to be consulted and to report upon an extensive railway scheme in southern Europe. The plans, some thirty-five in number, as drawn up by the Government Engineers were excellent in design and detail and moreover were in every way accurate. The financial arrangements, however, were framed somewhat on the lines which I have illustrated above, and as a consequence delay is being caused in the negotiations.

A great deal of English capital is at the present moment invested in foreign undertakings, but if the financial conditions were rendered more definite and reasonable, I feel confident that even more would be readily obtained for the advancement of enterprise in countries other than our own.

MOTOR INDUSTRY.—In a general address to members of the engineering profession the question of motor traction cannot be allowed to go unmentioned, owing to the fact that it has now become a part of that profession. Those who remember the first exhibition of motor cars at the Crystal Palace as far back as 1902 must find much food for reflection and even astonishment in the tremendous strides made in the few intervening years, in the development, both as to design and manufacture, of the motor-driven vehicle, and even more in the remarkable growth of the industry. I am given to understand that at the 1902 Exhibition the number of exhibits was less than 100 and cars manufactured out of England were in a large majority, whereas at the recent show of pleasure cars (it having been found necessary, owing to the continuous expansion of the industry, to hold a distinctive exhibition for commercial cars and motor boats) the exhibitors numbered considerably over 300, and it is extremely gratifying to note that British manufacturers were represented by a large majority. Moreover, Paris is no longer considered to be the centre of the motor trade, it being abundantly evident that London is becoming more and more the motor mart of the world.

The magnitude of the motor car industry may be gathered from the fact that at the exhibition held at Olympia under the auspices of that large and well-known society, the Society of Motor Manufacturers and Traders, Limited, in November last, visitors who desired to inspect cursorily every exhibit in the building had to traverse a distance of three miles in doing so, and the number of cars exhibited came somewhere in the neighbourhood of 600, in addition to fittings of all descriptions, engines, tyres, etc., the total value of the exhibits being close

upon half a million sterling. During the eight days the exhibition was open no fewer than 200,000 people were admitted.

From the above figures it will be easily realised to what an enormous extent motor engineering has developed both with regard to the needs of the pleasure-seeking public and to the ever increasing demand for expeditious, economical, and reliable transport for merchandise and materials.

NEW ROADS.—There can be no doubt that this form of transit has come to stay, and when this fact is considered the question of the reconstruction of our country roads is brought before us to an alarming degree. Some stringent alterations and improvements will, I feel confident, have to be made in the not far distant future to render our roads suitable for this heavy traffic and the increased velocity at which the cars are driven. The dust nuisance, too, about which one hears complaints on all sides, is one which must sooner or later be coped with.

It is to be hoped that we shall soon be informed that Local Authorities all over the country are seriously considering the carrying out of those improvements in our highways which have been rendered absolutely necessary by the incoming of the motor car, which before many years are past will, without a doubt, constitute perhaps the principal means of travel. By the execution of these improvements it seems reasonable to suppose that a great deal of the existing unemployment which is being so largely discussed throughout the country at the present time would be done away with.

To recommend an improvement of this magnitude is of course an easy matter, and it may be very reasonably argued that the expenditure necessary to carry it out would be enormous, but it must be remembered that by means of such an improvement many of the smaller towns where considerable business is carried on, but with no opportunity of expansion owing to the absence of railway communication, would be brought into touch with the larger towns, and thus by the introduction of motor traffic great commercial advantages would accrue to all concerned.

A complete report has recently been compiled by the Board of Trade on the traffic of London. The following extracts will doubtless prove of interest to you.

It states that while Paris has 102 miles of boulevards and avenues about 98ft. wide, London has only $8\frac{1}{2}$ miles, and while Paris has 42 roads radiating into the country, London with a population twice as large has only twenty.

The following table is also published, the figures of which are remarkably interesting, and shew the change in traffic at certain selected points in a single day in Westminster during the last few years. I should like to draw your attention especially to the

figures relating to the private horse vehicles, motor omnibuses, commercial motor cars, and taxicabs

This authority also state that road expenditure has diminished with motor traffic, and the labour of cleansing is reduced.

	1903.		1905.		1908.
2-wheel Cabs ..	5,114	..	5,260	..	5,042
4-wheel Carts ..	15,543	..	16,994	..	19,665
Private horse vehicles	43,790	..	47,833	..	29,967
Horse Omnibuses	32,790	..	32,661	..	15,216
Motor Omnibuses	—	..	537	..	10,914
Cycles	7,509	..	11,717	..	13,002
Private Motor Cars	1,064	..	3,260	..	6,961
Commercial Motor					
Cars	168	..	219	..	1,163
Taxicabs	—	..	—	..	19,718

AERONAUTICS.—An engineering Address in 1910 would be quite incomplete without some reference to aviation, a subject which has made stupendous strides during the past six months, and which has considerable interest for the engineer owing to the presence of machinery in the construction of aeroplanes. It is of course impossible to go into this subject with any attempt at detail at the present time, but no doubt in the near future we shall be entertained at one of our meetings by some enterprising member who will give us enlightening particulars upon this subject, which may, I suppose, as yet be considered to be in its infancy.

It is gratifying to note that British manufacturers are now turning out an all-British machine that can fly, and that quite recently Mr. Moore Brabazon has flown the straight mile; whilst the Hon. C. S. Rolls has within the last few weeks completed a flight extending over fifty miles and afterwards carried a passenger on his machine.

I am given to understand that the Isle of Sheppey, which until quite lately was practically unknown, is now becoming a place of some prominence, there being already a staff of over 200 men employed upon aeroplanes in the district. As a matter of fact ordinary accommodation is becoming very difficult to find. Several works are also developing rapidly in London. "Flyers" meetings, I understand, are to be held this year at Bournemouth, Eastbourne, Brighton, etc., to say nothing of the North Country meetings, and those who are immediately interested in this form of transport are, I believe, looking forward with considerable keenness and confidence to most rapid and satisfactory developments in this fascinating question.

At the Aero Exhibition which is to take place at Olympia in March next, actual flying machines which *have* flown and proved themselves capable in this respect will be exhibited,

and the public will doubtless see for themselves the great developments that are at present taking place with this form of transit.

EDUCATION.—I feel I cannot allow this occasion to pass without some reference to the educational portion of the young engineer's training. This is a subject which appeals to us all, and it particularly appealed to me during the time when I had the privilege of being a member of the staff of one of our well known institutions, viz., the Crystal Palace School of Engineering.

There are many members of this Society who are better able to speak upon this subject than I am, but I cannot help feeling that in the majority of cases where young gentlemen decide to take up engineering as a profession they do so under the erroneous impression that a few years' training with an occasional small amount of responsibility is sufficient to render them fully qualified and capable engineers, and in a great number of instances their chances of advancement and general success in the profession are marred to no inconsiderable extent by their eagerness and over-anxiety to "get out" and by the acceptance of appointments in small offices, after only, perhaps, two or three years' training. These appointments, as a rule, carry with them a small salary, which presumably is an attraction to the young student, but, unfortunately, such appointments are rarely to be obtained in offices where an extensive experience is likely to be gained.

I think you will all agree with me that it is absolutely necessary for those who desire to enter the engineering profession to do so with the full intention of giving several years to the study of its fundamental principles, both in connection with the drawing office and with the construction of works, before turning their attention to securing a position which will bring anything like a fair salary. Having thoroughly mastered the general principles and procured the essential experience, it is then for the young engineer to specialise and to turn his abilities and attention to the branch in which he desires to shine. As with all arts and professions, the groundwork must be thoroughly grasped and its details perfectly mastered before the student can hope to turn his talents to monetary advantage. If he is content to lay a sound foundation, experience and time will perform the rest.

The practice now adopted by engineers of spending some portion of their career with a contractor on public works is, to my mind, a really excellent procedure and one which ought to be more generally followed. The experience thus gained—and I can speak with experience—provided they are engaged with a contractor of good standing, proves invaluable to them in after life. They become thoroughly acquainted with prices, the transport of material, measuring up and setting out of work, and the various methods of carrying on the works which in the lecture hall at the engineering school they have heard so much about. He is

also initiated into the ways of the men employed on such works and the method of dealing with them ; while as the greatest and most necessary advantage of all, he is brought face to face with that feeling of responsibility which in after years will prove to be requisite in all his business transactions. In a few words, it may be said that experience cannot be altogether gained in a lecture hall or drawing office.

AMALGAMATION.—As I mentioned in the first part of my address, I will now say a few words with reference to the two bodies which now form our new Society, to the amalgamation of which I am confident we may look for gratifying results. This amalgamation, as you are aware, was not entered into by either of the parties without thorough consideration and careful investigation into the merits of the scheme.

Each of the component Societies has a record of establishment of more than half a century, which in itself is excellent evidence of their good standing, and their incorporation may, I believe, be taken to represent a unique event in connection with amalgamations of this kind. The Societies thus united, notwithstanding the fact that the work carried on by them in the past has been practically identical, had, when commencing their long career, very different objects in view. The older of the two—the Society of Engineers—dates back as far as May, 1854, when it was established under the title of the “ Putney Club ” its object at that time being the reunion of students of Putney College, an institution which existed at that period for the instruction of engineering students.

On the other hand, the Civil and Mechanical Engineers' Society is not very far behind the Society of Engineers in point of age, it having been founded in the year 1859 by the draughtsmen and pupils connected with the works of Messrs. Ravenhill & Co., marine engineers, of Ratcliff, E., and, unlike the older Society, has retained the original name. It is interesting and gratifying to note that their first Vice-President was Mr. A. F. Yarrow, M.Inst.C.E., who joined the Society of Engineers in 1861 and is still a very active member of this Society, while Mr. G. W. MacGeorge, the first President of the Civil and Mechanical Engineers' Society, died only last year.

The amalgamation, which has now been successfully accomplished, naturally necessitated the preparation of a Memorandum and Articles of Association and By-laws in substitution for the previous rules of the two Societies, and when we are informed that no fewer than nine separate drafts of the document in question were prepared before final approval was given to one of them, members can readily realise and may rest assured that the most minute details of the new constitution have been thoroughly

gone into by the gentlemen constituting the Councils of both bodies.

It was desired by the Councils to afford members of the incorporated Society every facility for active participation in the control of all matters in connection with the due and proper management of its affairs, and to open up channels by means of which effect may be given to the wishes of the majority of corporate members.

A reference to one or two of the clauses in the Articles of Association will not be inopportune at this moment.

In Clause 6 a provision is made that members of the profession who are specially qualified by long experience and examination may be elected into the new class of "Fellows." This class will therefore consist entirely of men of proved attainments and experience and who are holding responsible positions in the engineering world.

With a view to encourage an accession of junior men to the Society, the amount of the annual subscription payable by Associates under twenty-one years of age has been reduced to half a guinea. It is confidently believed that the adoption of this course will eventually prove itself to be a step in the right direction in the interests of the new Society.

With reference to a General Meeting of the new Society the regulations provide that a Special General Meeting shall be summoned on the receipt of the necessary requisition by the Council bearing the signatures of not less than two per cent. of all the Corporate Members, or convened by the Council at their discretion upon giving three weeks notice in writing to every corporate member, provision being made by which corporate members would be entitled to vote at such Meetings either personally or by proxy.

The Articles and By-laws also allow for the taking of a vote by post of the corporate members of the Society, a resolution duly carried by postal vote of the corporate members being held under the Articles to be equivalent to a resolution carried by the Society in General Meeting. By means of this excellent provision members who might, as is often the case, be prevented by absence from town or other business or private reasons, from putting in an appearance at a General Meeting would have an opportunity of expressing their opinions upon any questions which may be submitted for the consideration of the Society, and as a further recommendation for the adoption of the postal vote it will be seen that it will obviate the possibility of a small section of the members being called upon to give a decision on questions which should have the consideration of all the corporate members, and on which every member is naturally entitled to put forward his views.

It may be seen from Clause 2 of the By-laws that the method of voting for the purpose of electing new members has been greatly revised so that all corporate members entitled to vote may use the advantage of their privilege. The next clause is of the greatest importance inasmuch as it has been introduced with a view of placing in the hands of the members means by which they may nominate members of the Council.

An equally important provision with regard to the ballot and for the election of the Council of the Society is to be found by reference to By-law 5, which does not, as is usually the case, compel the Members to vote for a fixed number of candidates regardless of whether they are in a position to judge of the candidates' merits or not. Thus "mob voting" is entirely obviated and the voter is enabled to follow his own judgment as to whether he will give his vote or abstain from voting altogether for certain individuals.

The penultimate section of the By-laws has reference to the various privileges of membership, among which may be quoted here the granting of free legal advice on matters connected with profession, the loan of technical books from the Society's library, the Business Directory and Employment Register. The latter is not, I regret to say, in the flourishing state which it should certainly occupy, and it is hoped that all members of the Society who are employers of engineering assistants will, whenever possible, apply to the Secretary for particulars of men for whom they may have vacancies on their staff. I would especially call the attention of the members to the Employment Register in view of the increased number of junior members which it is anticipated will, under the new constitution, be attracted to the Society, and because I feel sure that, if properly supported, the Register will become an extremely useful and popular institution.

It is anticipated that the new constitution (if its adoption is coupled with the pursuance of the vigorous policy which it is hoped to carry out in regard to every proposal for the unification of the profession and the general advancement of engineering science in all its branches) will result in the extensive scope of the new Society's work being much enlarged, while at the same time ensuring a more rapid growth in influence and membership than has been possible with the two component societies.

It is a remarkable fact that no single vote against the amalgamation was received, though the ballot amounted to 50 per cent. of the joint membership. A hearty vote of thanks is due to the members for their great assistance.

REGISTRATION.—The very important subject of registration has been under the consideration of a great number of professional associations for some time past, and it certainly appears to me that on general principles, if this matter were carried through

it should be of advantage to the profession. Other professions are registered and why should ours be otherwise? At the present time, as you are all aware, so-called professional men who are entirely without experience or training, and who are absolutely unfit to design or carry out works of any description whatever, are often consulted in preference to a man of standing, and it is, I may say, the almost universal belief that registration would secure more opportunities for the fully qualified and competent engineer to obtain work; whilst it is my opinion that it would have the additional effect of greatly reducing the want of etiquette which now exists between members of the profession, an improvement which I feel sure you will all agree with me is greatly needed.

It is almost deplorable that the etiquette which has always existed in other professions is not to be found to any great extent in ours. Of course it cannot be gainsaid that some of the professions are not exactly on all fours with us—for instance the medical profession—but it is beyond all question that some improvement is greatly needed to place qualified engineers on a better footing, and I sincerely hope that something will shortly be accomplished.

COMPETITIONS.—Another practice with which engineers have nowadays to contend is the utterly inadequate and in some cases puerile inducements held out in instances where competitive schemes are invited from various branches of the profession. Even though the competitor may of necessity spend many pounds in travelling, to say nothing of time and materials, or on the other hand the total disbursement in the preparation of a scheme only amounts to a few pounds, the reward offered by those who invite engineers to compete is in many cases barely enough to pay railway fares, and in order to obtain this “distinction” he must be first on the list. Again, a competitor may be fortunate enough to be placed first by the umpire, and is naturally elated at the thoughts of securing the work of supervising the construction of the scheme from his design, but as we all know, it very often happens that he either has the pleasure of seeing someone else carry out his scheme, or the scheme is shelved for an indefinite period by the Authority and the winner of the competition rests on his laurels and the small “prize” which eventually constitutes the outcome of his labours.

This is extremely hard upon those who may be entering these competitions, as a great many do, with the view of starting a practice, should they be fortunate enough to be awarded a “first” by the Assessor, and it seems a great injustice to the profession as a whole that Local Authorities should offer such inadequate terms as can so often be seen advertised in the engineering papers.

In concluding this Address I beg to thank you for your attention and would mention that I have done my utmost to render it as interesting as possible, whether I have succeeded in this respect does not of course devolve on me to say, but I have endeavoured to make reference to most points in connection with this great and honourable profession of ours, and at the same time to deal in a comprehensive yet condensed manner with what I will call the household affairs of the new Society.

Mr. W. B. Esson : Gentlemen, it is with the greatest pleasure that I rise to ask you to accord your most hearty thanks to the President for the excellent address which he has delivered. He has proved his versatility as an engineer inasmuch as he has traversed the whole range of engineering from what might be called the earliest section, that is, the supply of water, to the very latest, that is, aviation. You will have observed that in his address he has dealt with the important problems of both sewage and water supply. In the Civil and Mechanical Engineers' Society we have been treated to a great many papers on sewage disposal, but none that I can remember on water supply. I regard the fact that the President of the new Society has mixed with the sewage a proper quantity of water as a good omen, and as indicating that he has the proper sense of proportion for a President. It is an unwritten law that one must not criticise a Presidential Address. In the present case there is really nothing to criticise but everything to praise. I was greatly struck with the remarks about the motor industry. There are many ways of estimating the efficiency of motor cars. In 1902 the efficiency of a motor car was about 20 per cent., that is to say, for every twenty hours that you were on top of the car you had to spend eighty hours underneath it doing something to the machinery. Now the efficiency of a motor car is something like 90 per cent., and one can safely assume that for ninety hours in the car no more than 10 will be required underneath. With these remarks, gentlemen, I ask you to give your best thanks to the President for his admirable address and I trust he will permit of its being published in the transactions of the Society.

Mr. Maurice Wilson : Gentlemen, it gives me particular pleasure to second this proposition as I think that I can claim to be the President's oldest friend in this room. Comparisons are odious, but I think that you will agree with me that this address has been one of the most interesting that we have had for a good many years. I feel sorry that more members are not present. I have no doubt that they will read it with much gratification if the President will kindly allow it to be published with the transactions.

The vote of thanks was carried with acclamation.

The President (Mr. Diogo A. Symons), in thanking Mr. Esson, Mr. Maurice Wilson and the meeting for the vote of thanks, said that he could quite understand that there were several gentlemen who would like to have the opportunity of cross-examining him on several of the questions which he had raised. As that was out of order at that meeting, he hoped on some future day to read a paper to the Society embodying some of those questions, which would be open to discussion.

He was professionally associated with the Aero Show, but not as an aeronaut. If any one present would like to have a fly he might be able to arrange it, but he could not take any responsibility for the consequences.

March 7th, 1910.

FRANCIS GEORGE BLOYD, VICE-PRESIDENT,
IN THE CHAIR.

SEWAGE DISPOSAL IDEALS.

By W. C. EASDALE, M.R.San.Inst.

[Member.]

AN ideal is defined as a conception of perfection, visionary and unattainable, and may perhaps be considered of little value to the members of a Society whose aims are, or should be, before all of a practical nature. On the other hand it is recognised by many that an ideal, however unattainable it may seem in the rough and tumble of everyday life, may be very useful in stimulating efforts towards its attainment and thus bring about improvements which otherwise would not be effected. The multiplicity of methods and combinations of methods in use at the present time in works of sewage disposal, and the large number of factors to be considered in forming a correct judgment as to the most suitable scheme to adopt for any particular case, would seem to make it very difficult to set up even the semblance of an ideal towards which workers in this field may aim. When the subject is considered in all its bearings, however, there are certain definite principles upon which all schemes must be based, and it seemed to the author that it might be worth while to attempt to set forth these as concisely as possible in the hope that they might be of some small value for reference to those who are engaged in this branch of engineering.

GENERAL PRINCIPLES.

In the first place it is necessary to state the purpose of sewage disposal. Broadly speaking it may be defined as the disposal of all liquid wastes in such a manner as to prevent the creation of any nuisance, and at the lowest possible cost. The question of cost is, and must be, subsidiary to that of the prevention of nuisance, and the ideal which every engineer should set up when preparing a scheme of sewage disposal is efficiency first and cost second. No doubt many local authorities and private clients exhibit strong tendencies to reverse this order and give instructions to the effect that the work to be done must be the minimum which will enable them to meet the requirements of the case. These requirements are usually the regulations of the Local Government Board. In some cases, however, it is simply a question of complaints from a neighbouring authority or from some riparian owner or rivers board, or from owners of shell-fish layings, or again from the ratepayers themselves; complaints which are frequently considered by the client to be exaggerated. In other cases the client is obsessed with the idea of economy

regardless of all other considerations. In circumstances like these the engineer should show his clients the futility of restricting his operations by limiting the cost, and should explain very clearly that a scheme involving low initial expense often proves to be the most costly in the end if efficiency is not given primary consideration. The ideal in this connection is for the engineer to receive a free hand in designing his scheme, the only stipulation being that the works when in operation shall be efficient and satisfactory in every respect.

It may not be out of place to refer here to the question of competitions. It is impossible to condemn these too strongly. Most engineers are agreed that competitions, as ordinarily conducted, have a baneful effect upon the reputation of the profession, and it does not seem possible to impress on local authorities the dangers they incur by this method of obtaining schemes of sewerage and sewage disposal. It is argued in some quarters that properly conducted competitions are useful in affording young engineers opportunities, which they cannot otherwise secure, of shewing what they can do. Against this it may be pointed out that very few competitions are properly conducted, and that in matters of sewage disposal, more than in any other branch of engineering, practical experience is required to design satisfactory schemes, so that the young engineer has a very poor chance of winning a place. There is also the tendency to adopt a scheme purely on the basis of estimated cost, regardless of other considerations. This influences the competitors to submit schemes which can be cheaply constructed, and also to base their estimates upon the lowest possible prices without making any provision for exceptional difficulties of construction or unforeseen expense. If such a scheme is actually adopted the ultimate outlay is found to be greatly in excess of the preliminary estimate, and the engineer, and his profession generally, is blamed for the result. It is not uncommon for local authorities and private individuals to complain of the futility of engaging consulting experts to advise them on engineering matters, and for this unsatisfactory state of affairs engineers themselves are alone to blame. It would therefore seem advisable for engineers to set themselves a high ideal in the matter of competitions and preliminary estimates, and in the author's opinion it would lead to greater confidence being placed in consulting engineers if all were to refrain absolutely from taking part in competitions of any kind, and from giving preliminary estimates which are not based upon ample prices and do not cover every contingency that can possibly be foreseen.

PRELIMINARY CONSIDERATIONS.

In preparing a scheme of sewage disposal there are many points which need careful study before the actual works can be considered. In the first place the question of site must be settled. The ideal site is one which is sufficiently removed from

the neighbourhood of dwellings to prevent any possibility of nuisance arising. It should also be situated so that all the sewage may be delivered at the works by gravitation, and the nature of the subsoil should be such that it can be utilised, if not for land treatment alone, at any rate for the final stage after treatment in tanks and filters. Conditions such as these are undoubtedly a counsel of perfection and are seldom available, but every effort should be made to secure them. There is as a rule no difficulty in complying with the conditions as to distance from dwellings, but if all the sewage cannot be delivered by gravitation, only that portion of the sewage which is below the level of the outfall should be pumped, and the remainder should be allowed to gravitate. It is true that the extra initial cost of pumping plant capable of raising the whole of the sewage is in some cases not much in excess of that for the volume which must of necessity be raised, but the continuous annual charge for operating the pumping plant is a most important consideration, and should be reduced to a minimum. Even when a pumping scheme has been decided upon it is frequently not possible to secure a site where the character of the subsoil is suitable for the purpose of irrigation. In these circumstances it is useless to recommend the purchase of any greater area than will suffice for the actual works required, with due provision for probable future extensions. Although it is a difficult matter, the question of the cost of the land should receive careful consideration, especially where two or more suitable sites are available.

Having chosen the site, the next problem to be considered is what method or combination of methods should be adopted to secure the desired result at the lowest cost both for construction and maintenance. This is probably the most important and the most difficult part of the engineer's duty. It is not sufficient merely to copy some existing installation which is successful under probably entirely different conditions. The two principal factors in the solution of this problem are the character of the sewage to be treated and the extent to which it must be purified. If the sewage is of purely domestic origin there is not much difficulty in selecting a method which will satisfy all reasonable requirements, but, if it contains a large proportion of laundry wastes, brewery liquors or other trade wastes, great caution must be observed in coming to a decision and it is in these cases that the engineer has the greatest need of practical experience. Text-books and reports of Royal Commissions and other expert authorities may be studied assiduously, but will be of little avail if the engineer is not in a position to form a correct judgment on the basis of his own experience. It may be argued that all engineers cannot possibly obtain practical experience in the disposal of all kinds of sewage, but if any engineer is confronted with the problem of dealing with some special type of sewage of

which he has had no experience it should be his duty to secure the assistance of some brother engineer who has the necessary qualifications.

Another important factor in the selection of the most suitable method of treatment is that of fall. If there is not sufficient fall for any particular scheme unless pumping is resorted to, and some other equally suitable method can be arranged to do without pumping, the latter should be adopted. From the foregoing it will be seen that there is great scope, even in the preliminary considerations, for the exercise of ingenuity and experience on the part of the engineer in designing a scheme which will satisfy the ideal under the conditions at his command.

GRIT CHAMBERS AND SCREENS.

The method of treatment having been decided upon it becomes necessary to consider the details of the scheme. There would not appear to be much room for setting up an ideal in connection with grit chambers and screens, yet even these minor details may be more or less satisfactory in their design. The purpose of a grit chamber is to arrest as much as possible of the mineral matter in the sewage and not to retain any organic matters in suspension which can be dealt with in subsequent stages, due regard being had to the character of the sewage. As the mineral matters deposited are not acted upon or reduced in any way they must sooner or later be removed, and it is in the lack of means for the removal of the deposit that grit chambers usually fall short of the ideal. In the author's opinion frequent removal (daily if possible) is the most satisfactory system to adopt. It is more likely to be done regularly if it is made a daily operation than if it is performed at irregular intervals, and the quantity removed is less in bulk, and thus more easily disposed of. On the other hand it is difficult to enforce frequent and regular removal when proper facilities are *not* provided. The ideal grit chamber is of such construction that it arrests *all* mineral matters but *no* organic matter, and is provided with every facility for removing the deposit at regular and frequent intervals.

With regard to screens the author has seldom observed screenings from any type of screen, the larger portion of which might not have been allowed to pass into the subsequent tanks without increasing the quantity of sludge by more than an infinitesimal fraction of its total volume, and he considers their use, except in pump wells, and a few other exceptional cases, as unnecessary. As, however, the Royal Commission hold the contrary opinion it will be necessary to provide screens in many cases, and the ideal screen is one that will perform the work it is expected to do without becoming choked too readily, and thus backing up the sewage. This ideal is probably unattainable, but there is no reason why engineers should not attempt to approach as nearly as possible to perfection. Among the very

usual defects are want of width, and lack of depth below the water level ; and one of the most difficult problems to solve is the suitable spacing of the bars—that they shall be sufficiently narrow to arrest the matters they are required to intercept, but wide enough to allow all others to pass. The use of mechanical methods of cleaning screens tends to prevent frequent choking, but even in these cases the matters arrested are generally of such a nature that they might be allowed to pass into the tanks, and there are a large number of small works where mechanically operated screens cannot be used.

TANKS.

The term “ multiplicity of methods ” used at the commencement of this paper applies probably with greater force to the preliminary treatment in tanks than to any other stage of the process. The Royal Commission in their fifth report deal with five different types, namely :—Chemical precipitation, quiescent and continuous flow ; sedimentation, quiescent and continuous flow ; and septic tanks. To these may be added Dr. Travis’s hydrolytic tank, Mr. Dibdin’s slate beds, Mr. Scott-Moncrieff’s cultivation tank, the Imhoff tank, Mr. Commin’s separator, the Fieldhouse tank and many others. Each of these methods has its supporters and some may be more suitable than others for particular conditions or special requirements. As the function of all preliminary processes is to arrest the solids in suspension and provide an effluent suitable for the final process of oxidation in filters or on land, it is obvious that the type of filter to be used must also be considered in deciding upon the best form of preliminary process to adopt. Some prefer to throw the greater proportion of the work upon the tanks, others upon the filters. In the former case the sludge problem is intensified ; in the latter there is less sludge but the filters require greater attention and the final effluent must be settled or filtered before it can be discharged into a watercourse. In one case with which the author is acquainted the use of sedimentation tanks produced a certain amount of sludge which presented difficulties in disposal, and an excessively large quantity of humus in the final effluent. By adopting chemical precipitation the sludge was more easily handled and there was practically no humus in the final effluent. Again, as experience has shewn that the reduction of the amount of sludge which it was originally anticipated would take place in septic tanks cannot be relied upon in actual practice, the question has arisen as to how far the putrefactive process in tanks can be carried without adversely affecting the subsequent treatment in filters. Some have said that the preliminary stage of purification must necessarily be an anærobic one—that in order to purify one must putrefy. Others have questioned this statement and have expressed the opinion that there does not appear to be any foundation in fact for this view, and that it has

been shown to be possible to purify sewage entirely under aerobic conditions. The Royal Commission in their fifth report state that effluents from septic tanks are *not more easily oxidised* than those from chemical precipitation or from simple settlement tanks—a negative conclusion, but one which has some bearing upon the statements made by advocates of the use of septic tanks. The author favours the view that septic action is not essential. In many cases the conditions under which sewage finds its way to the outfall necessarily involve a considerable degree of putrefaction due to the time required for it to flow through long lengths of sewers. It would, however, appear to be worthy of careful consideration whether it is advisable to provide tanks or other means for increasing the degree of putrefaction in sewage already in a more or less septic condition, or to cause putrefaction even in the slightest degree in sewage which reaches the outfall in a fresh state. On this point reference may be made to some interesting experiments which may have escaped general notice. The investigations were made by Mr. Scott-Moncrieff, whose advocacy of preliminary treatment or hydrolysis under anaerobic conditions is well known, and the results were published in a paper read at the Sanitary Congress at Cardiff in 1908. The sewage was tested under three different conditions, with periods of hydrolysis in the cultivation tank of 22 and 4 hours, the cultivation tank being omitted altogether in the last experiment, so that the sewage reached the filter in a fresh condition without undergoing any process of anaerobic hydrolysis. The albumenoid ammonia figures in all three effluents were practically the same, but the oxygen absorbed figures were slightly higher in the case of the effluents after 4 hours period of hydrolysis and from the raw sewage. On the other hand the nitrates were considerably higher in the effluent after 4 hours hydrolysis, and from the raw sewage than in those which had undergone 22 hours of hydrolysis in the cultivation tanks.

	FINAL EFFLUENTS.		
	Albumenoid Ammonia.	Oxygen absorbed in four hours.	Nitrates.
	Parts	per 100,000	
After 22 hrs. hydrolysis in cultivation tanks	0·06	0·16	0·7
After 4 hrs. hydrolysis in cultivation tank ..	0·08	0·64	1·6
From raw sewage quite fresh (no anaerobic treatment)	0·06	0·32	1·6

The above table gives some figures taken from the analytical results given in Mr. Scott-Moncrieff's paper. One of the immediate objects of these investigations was to discover what were the periods of hydrolysis that gave the necessary standard of purification under measured conditions of flow, and periods between each discharge of the septic effluent upon the filtration surface. From the table it would appear that the necessary standard of purification was obtained *without any period of hydrolysis at all*, that is, under entirely aerobic conditions, and the results are specially noteworthy for the reason that they are quoted by an expert who has consistently advocated the necessity of preliminary treatment under anaerobic conditions.

The foregoing results are mentioned here as an argument in favour of the opinion that anaerobic conditions involving putrefaction are not essential in the purification of sewage.

On the other hand the author is prepared to admit that preliminary treatment in tanks of some kind or other may, under certain conditions, be desirable, but there is undoubtedly a growing tendency to avoid carrying the process of putrefaction to such a stage as to produce offensive odours. Where it is absolutely essential to prevent the slightest smell, Dibdin's slate beds might be adopted. In other cases the character of the sewage or the requirements of the oxidising filters may need some other form of tank treatment, and consideration of the points which have been raised shews that it is impossible to formulate any rule which may be generally applied to all cases. The nearest approach to any definition of the ideal form of preliminary treatment of sewage in tanks is thus probably somewhat as follows:—The treatment must be such that it is adapted for the particular character of the sewage to be dealt with, and will produce the most suitable effluent for the filters, while at the same time reducing the quantity of sludge to be dealt with to the minimum and also preventing the possibility of nuisance from smell.

Although no particular system of preliminary treatment in tanks can be accepted as the ideal process, there is less difficulty in forming an opinion as to the ideal methods of constructing such tanks. One of the most important points is to secure a uniform rate of flow through the tanks and over their whole area. In arriving at this ideal, special attention must be devoted to the arrangement of the inlets and outlets by making them in the form of weirs, or if in the form of pipes, by having a large number of inlets and outlets to each tank. Again, the efficiency of the process of sedimentation is in the author's opinion greatly affected by the factor of depth. It is not sufficient to say "let us make the tanks 6ft. deep." Careful study should be made of the specific gravity of the matters in suspension and the velocity of discharge at the outlet. Another matter which does not

always receive the attention it deserves is the method to be adopted for removing the sludge. It is usually possible, by careful design, to arrange the sludge removal in such a manner that it is not necessary to discharge the entire liquid contents of the tanks, and in this way much expense in operation may be avoided.

FILTERS.

Passing now to the question of filters it may be remarked that at the present time by far the greater number of new schemes include percolating filters. There are, however, still a few advocates of the contact bed system. The chief objection to the use of contact beds has been that they rapidly lose their liquid capacity, and in this respect there is good reason for complaint in connection with these beds as ordinarily constructed. In the author's opinion the chief causes of this difficulty are want of fall on the floor and lack of ample subdrainage. In a very large number of cases the slope of the floor is barely sufficient to allow clean water to flow freely to the outlet even if there were no material in the bed, and it is totally inadequate for the complete discharge of an effluent which is more or less charged with suspended matter. If to this is added the obstruction caused by the filtering material laid in close contact with the floor there is little wonder that the suspended matters are arrested and retained in the material and thus rapidly choke the interstices. Percolating filters require that the suspended matters which pass away in an effluent shall have a free outlet, and for this purpose false floors are provided, as well as a good fall on the floor. It should be recognised that the same condition is necessary in the case of contact beds, and if this condition were observed, there would seldom be any cause for complaint as to the choking of contact beds. On the other hand the volume of sewage which can be satisfactorily treated in contact beds is limited to about one filling per day in dry weather and at the most three fillings per day with a diluted sewage in wet weather. It is true that when dealing with a good effluent from chemical precipitation tanks, contact beds may be filled as often as six times per day for considerable periods, but the fact remains that the necessity of securing ample periods of rest empty for oxidation, in addition to the time occupied in filling and discharging contact beds, limits the volume that can be properly purified by this method. Percolating filters, on the contrary, have no such limitations, but can be operated continuously and, where the sewage is weak in character or of average strength, percolating filters have an advantage in this respect over contact beds. Where the fall available for the disposal works is limited to five feet it is difficult to apply percolating filters with success, but it is quite possible to introduce a set of double contact beds, and under these conditions it would be advisable to consider their adoption,

especially if by that means the annual expense of pumping can be avoided. In the author's opinion the system of contact beds is not yet obsolete and may be adopted with advantage under certain conditions. Further, he considers that where contact beds have failed to fulfil expectations the causes may be found in faulty design and a want of knowledge of the proper conditions required to secure the best results. It may therefore even now be of some value to endeavour to define the ideals which should be aimed at in the design of these beds, and it may be observed that if the following details of construction and operation are rigidly adhered to it will be found that there will be very much less reduction in the liquid capacity of the material and a correspondingly longer life of the beds.

In the first place the beds must be absolutely watertight. The gradient of the floor must be such that it will give a self-cleansing velocity towards the outlet. (This point has received very little consideration in the past, and in a number of cases the floors have been laid with no fall whatever.) The whole area of the floor should be covered with a perforated false floor so that the filtering material does not rest on the floor of the bed itself. The filtering material must be carefully selected—not liable to disintegrate but vesicular in form—(hard-burnt vitrified furnace clinker is undoubtedly the best), and carefully graded. For primary coarse beds the grading must be adapted to the character of the tank effluent, but the size of the particles for the fine beds should never exceed half an inch in diameter with a minimum of one-eighth inch. The time occupied by the periods of filling, standing full and discharging each bed should in no circumstances exceed four hours, and the beds should never receive more than one filling per day in dry weather when charged with sedimentation or septic tank effluents.

* MATERIAL FOR PERCOLATING FILTERS.

With regard to percolating filters the ideal for the material is the same as for contact beds, but there is considerable difference in opinion as to its size. On this point much depends upon the amount of suspended matter present in the tank effluent. Fine-grained material will produce better results than coarse, but it rapidly becomes clogged if there is much suspended matter in the tank effluent and in that case a coarser grained material will prove more efficient in the end. On the other hand a coarse material will discharge a larger amount of suspended matter with the effluent in the form of humus, and it becomes necessary to decide whether the suspended matter shall be arrested on the surface of the filter by using fine material or, by using coarse material, allowed to find its way into the filter and pass out in the final effluent. In the author's opinion it is much less trouble to settle out the humus in the effluent than to attempt to remove it from

the surface of the filter by using fine material. In some cases a considerable amount of trouble is taken to grade the material in successive layers but there is usually very little justification for the extra labour involved. On the other hand it is even more important not to mix fine and coarse material together in the body of the filter, as the smaller particles have a tendency to be washed down and close the interstices between the large pieces, thus preventing the free access of air which is so essential to the continued efficiency of the filter. In the author's opinion the best method to adopt is to have the whole of the material, with the exception of the bottom layer of large pieces immediately over the false floor, as nearly as possible of one grade.

FLOORS.

The recommendations as to the necessity of providing a perforated false floor over the whole area of the filter and constructing the floor with a suitable slope, previously made in connection with contact beds, apply with equal force to percolating filters.

DEPTH.

With regard to the depth of these filters, much depends upon the character of the sewage to be treated, upon the nature and grading of the material and, above all, upon the method of distribution. Within certain limits, however, it is generally found that the same quantity of sewage can be satisfactorily treated per *cubic* yard of material whether it is in the form of a shallow or deep filter.

DISTRIBUTION.

The question of distribution is of prime importance but it would need an entire paper of this length to deal fully with the various methods in use, and their advantages and defects. On this occasion it must suffice to say that the ideal method is one that produces the nearest approach to perfection in uniformity of distribution above the surface of the filter, and that the greatest efficiency is secured by a slow continuous rate of distribution rather than by intermittent doses at higher rates. In cases where the rate of flow varies to such an extent that it is insufficient, at times, to provide the necessary motive power to rotate the distributor, a dosing arrangement is essential. The opinion is held in some quarters that an intermittent supply is desirable in any and all circumstances in order to provide intervals for aeration. It has apparently been overlooked that with distributors having four arms the ratio of the period of actual discharge per foot of travel to the interval of rest for aeration is, on the average, as 1 to 30. When operated continuously at the rate of say 300 gallons per square yard per day the actual rate per minute is 0.25 gallons. If an equal volume per day is distributed

intermittently at intervals of $7\frac{1}{2}$ minutes, as suggested by some experts, it is obvious that, even if the duration of the discharge is $1\frac{1}{2}$ minutes, the actual rate at which the liquid is delivered to the filter must be five times the rate at which it would be delivered if the distribution were continuous, or 1.25 gallons per square yard per minute. As the essence of the principle of treatment in percolating filters is the slow passage of the liquid in a thin film over the filter material, the arguments set forth above would appear to be entirely in favour of continuous distribution where possible.

HUMUS TANKS.

It is now generally recognised that coarse-grained filter or contact bed effluents contain a certain amount of matter in suspension in the form of humus. When discharged into a comparatively large body of water these suspended matters seldom cause any trouble. On the other hand, when discharged into small streams, some of which dry up in summer, these matters may form deposits which, although they do not create a nuisance, are unsightly. In order to produce the ideal final effluent therefore, these suspended matters should be removed. This can be effectively done by passing the effluent either through fine shallow filters of sand or clinker dust, or through humus settling tanks. The question as to which is the most suitable method to adopt depends upon local circumstances, especially with regard to the most convenient means for removing the humus when it is arrested. Sand filters are the most efficient as they not only remove the matters in suspension but provide an additional degree of purification from the bacterial, if not from the chemical point of view. It, however, the question of cost is paramount then properly constructed and operated humus settling tanks are probably the most suitable.

There are two matters of importance, sludge disposal and methods of operating contact beds, which have not been dealt with in detail in this paper. The reasons for this are, that they pertain rather to management than to construction, and further, the author has already recorded his opinions on both subjects very fully in another place.

GENERAL CONSTRUCTION.

There is one other question upon which it may be desirable to suggest an ideal and that is the question of general construction. Some engineers have a very natural inclination to construct works which shall, when completed, make a "good-looking job." Upon those who have no knowledge of the essentials of a sewage disposal works it certainly creates a good impression to see substantial walls, well rendered and coped with blue bricks or stone, the buildings faced with stone, and a little ornamental brickwork here and there. At the other extreme are those who

sacrifice everything to economy, occasionally to such an extent that the walls, for example, fail to withstand the pressure they are required to take, or the filtering material rapidly disintegrates. In the opinion of the author the ideal works are executed in such a manner that while they are constructed throughout in a substantial manner and of materials which are the best of their kind, they should contain nothing which has not a direct bearing upon their efficiency in the production of a satisfactory effluent and their maintenance in a good condition at the least possible outlay for repairs.

In conclusion it may not be out of place, at the risk of being accused of stating platitudes, to say that, as in all other branches of engineering, experience is absolutely essential in attempting to reach the ideal in the construction of works of sewage disposal. No amount of study of the literature on the subject will be of any avail without long continued, practical experience of the many methods and combinations of methods which are in actual use under varying conditions. No sewerage engineer would dream of undertaking the construction of an aeroplane, nor would a purely aeronautical engineer undertake the design of large docks or water reservoirs. Yet engineers with as slight a knowledge of the essential principles of sewage purification by modern methods do not hesitate to design and carry out works of sewage disposal. The result is that owners of estates and local authorities are less and less inclined to employ engineers, even those who have made a special study of the subject for many years. The natural conclusion is that engineers must specialise more than ever and it would tend to improve the status of the engineering profession if each member would make a point of sticking to his last.

The author is well aware that a large number of details in connection with the construction of sewage disposal works have not been dealt with in this paper, but the subject is so extensive and involves the consideration of so many varying conditions that it would serve for several papers of this length. He hopes, however, that the attempt here made to define the ideals which should be aimed at in such undertakings may be of some value to those who are engaged in this branch of engineering and thus assist even in a small way in the production of works which may be a credit to the profession.

DISCUSSION.

The Chairman moved a very hearty vote of thanks to Mr. Easdale for his paper. In starting, Mr. Easdale had described what an ideal should be, and in the concluding paragraph of his paper he had expressed regret that there were a large number of details in connection with the question of sewage disposal with which he had been unable to deal. Those details would perhaps come out in the discussion.

The vote of thanks was unanimously agreed to.

The following written communications were read by the Secretary :—

Dr. Gilbert J. Fowler wrote :—

I would venture to emphasise an opinion, now, I think, more generally held than formerly, but which appears to be overlooked in Mr. Easdale's paper, that the design of works, particularly when special difficulties are present *re* trade effluents, etc., is a matter requiring the co-operation of the chemist and engineer. The construction of works is a more purely engineering problem.

I should like to express my agreement with Mr. Easdale in regard to the method of construction of contact beds.

Mr. Arthur J. Martin wrote :—

I have read Mr. Easdale's paper with great interest, and very much regret that I cannot hear it discussed.

I should like to take this opportunity of congratulating the Society on the great "ideal" of unity which they have realised and to wish them a long, honourable and prosperous career.

I must also congratulate the Society on having secured a paper from Mr. Easdale, whose knowledge of the subject on which he writes is only equalled by the fairness and moderation with which he states his views.

It is refreshing, in these days of pessimism, to find someone who tells us to aim high. There is a tendency nowadays to magnify difficulties, and to put up with low standards of attainment.

For my own part I am sceptical as to the existence of impossibilities, except in a limited number of cases. In other departments of engineering the steam turbine, the high potential dynamo and the linotype machine have been perfected in the teeth of difficulties as great as any which we have to encounter ; and if the problems of sewage disposal are tackled with the same thoroughness and with the same determination, there is no reason to doubt that they will be solved.

One of the greatest hindrances, if not the greatest, to progress in this field has been the habit of regarding all sewages as being practically identical in composition and strength, and attempting to purify them on the same lines, and even with the same allowances of tank and filter capacity. The hard and fast rules which have been in vogue remind one of that hospitable oriental potentate who was so anxious that his guests should sleep comfortably in the bed which he had provided for them that, if the guest happened to be too short for the bed, he stretched him to fit it, and if he were too long, he cut him down to the proper length. There is nothing of this in Mr. Easdale's paper. He does not put forward any pet process, and tell us to expect all sewages to conform themselves to it ; but he rightly insists that the mode of treatment should be chosen to suit the sewage.

The Royal Commission are hardly so emphatic in their recommendation of screening as he seems to imply. All that they say is that screening "is almost essential where the sewage has to be pumped, and in other cases is usually considered an advantage." One would certainly hesitate to put in screens at small works, where a man is not constantly in attendance to keep them clear.

The author hits the nail on the head in his remarks as to the causes of failure of contact beds. The contact bed has always been the "Cinder-ella" of sewage works, and the trickling filter the "Pampered Sister." In the case of the latter every care has been lavished on its construction, ventilation and drainage, and on the selection and grading of the filtering material. The contact bed on the other hand has too often been nothing more than a promoted ash-heap, dumped haphazard into a barbarously constructed receptacle, and utterly innocent of drainage. The trickling filter has been permitted, in fact encouraged, to void any solid matter which it has been unable to digest. But what has been a virtue in the trickling filter has been a sin in the unfortunate contact bed. The outlet of the bed has usually been throttled for the express purpose of preventing the undigested residuum from being washed out, and then the bed has been blamed for sludging up.

The adoption of the author's suggestions for the construction of contact beds would go far to redeem them from the discredit into which they have fallen.

It is somewhat surprising that so experienced an observer as Mr. Easdale should speak of three fillings of diluted sewage per day as the utmost which a contact bed can satisfactorily treat in wet weather. It is true that he makes an exception in favour of precipitation effluents, but I have found no difficulty in dealing with dilute septic tank effluents at the rate of five fillings per day. Where trouble has been experienced in increasing the rate of working in wet weather, it has probably been due to the attempt to maintain the periods of filling and resting full at their ordinary length, at the expense of that for drainage and aeration.

The author deprecates the undertaking of schemes of sewage disposal by men who have not had any previous experience of such work. But what else could be expected, when it was dinned into our ears that one method was radically wrong, and another the only one which ought to be adopted, and that the capacity of tanks and filters could be settled by a few simple rules? If local authorities and private clients are to appreciate the need for judgment and experience in dealing with cases of sewage disposal, they must first be taught that the design of sewage works is not a mere matter of rule of three, and that there is no one process or combination of processes which is applicable in all cases.

Mr Easdale's paper is a valuable contribution in this

direction, and I hope that his remarks on the subject will be strongly emphasised in the course of the discussion.

Mr. Hugh P. Raikes wrote :—

I have read Mr. Easdale's paper with great interest and entirely agree with his views regarding the mistaken policy adopted by so many local authorities in inviting competitions for engineering works.

There can be no question but that this policy almost invariably results in an enormous waste of the ratepayer's money, without any advantage or credit to the engineer employed or anyone else concerned.

Mr. S. R. Lowcock, in opening a discussion on the paper, thanked the Council for having invited him to attend the meeting, and expressed a wish that the incorporated Society might have a long and prosperous career.

The Society had been fortunate that evening in having a very practical paper ; for Mr. Easdale had had a very large experience in the everyday duties of a manager of works, and the operations connected with the purifying of sewage in those works. Mr. Easdale looked at the subject largely from the point of view of the works manager. He had given most useful information and suggestions to engineers in designing works and he (Mr. Lowcock) would take the present opportunity of acknowledging his own indebtedness to Mr. Easdale in that respect.

With regard to ideals it was perfectly true, according to the old maxim, that the man who aimed at the moon shot higher than the man who aimed at a tree. One ideal in the matter of sewage disposal was of course a good effluent. If they had an ideal as to an effluent, they practically had a standard. A great many years ago it was said that they could not have a standard, but he had always contended that they had a standard, because every Medical Officer of Health, every analytical chemist, and every sewage engineer knew perfectly well in his own mind what was a good effluent, what was a middling effluent, and what was a bad effluent. This might not be set down in hard black and white figures, but the very fact of his knowing showed that he had a standard.

With the greater part of the paper he was in entire agreement, and he agreed entirely with what Mr. Easdale said about competitions. There were two difficulties which were not mentioned in the paper. One of them appealed to the engineer and to the authorities, and the other to the authorities more particularly. The first was that no man who was going in for a competition could possibly discuss all the points that ought to be discussed before he designed his sewage scheme. The Council and the officers had not the time to go through all the

various points with every one of the competitors ; and many of the points were matters of policy or tactics and not of engineering. The result was that the scheme could not be satisfactory either to the engineer or to the authorities. The other point was that authorities were generally simply wasting money by inviting competitions. If they had an engineering assessor to advise them on the schemes sent in they would probably—perhaps he might say certainly—have the best scheme out of the whole ; but if they did not appoint such an assessor they would probably take what appeared to be the cheapest, and thus waste their money. On the other hand, if they appointed an assessor they had to pay him his fee and probably further fees for the alterations he might find it necessary to make in the selected scheme, and in the end they would have to expend a great deal more than if they went to a responsible engineer at first.

The author had spoken of pumping as being a fearful bugbear but he (the speaker) would like to suggest that pumping was not a very serious thing. It was better to spend a little money in pumping than to spoil the scheme by putting in the sewers with insufficient gradients and not giving enough fall through the works to enable proper purification to be effected. When they considered that on a fair-sized scheme they could lift 1,000 gallons 100 feet high for a farthing, the cost of pumping was not such a serious matter. Later in the paper the author referred to grit chambers and screens. He (Mr. Lowcock) entirely endorsed what was said about removing the deposit in the grit chambers and the screens as frequently as possible. He should like to extend the same practice to the other parts of the works—clear them out as frequently as possible. If they had a form of tank from which they could draw off some sludge every day they would, according to his experience, get a better result in that way than by any other means.

With regard to screens he quite agreed with the author as to the faults. The fault most frequently found with a large number of screens was that they only reached to the bottom of the chamber, which was on the same level as the invert of the sewer. If they had a considerable space below the bottom bars and below the invert of the sewer, with a sloping screen, the heavier matters would fall from the screen and could be raked up an incline. He did not agree that screens were not necessary, because a great deal of organic matter which was not broken up came down to the works. He quite supported the author in the opinion that anaerobic conditions involving putrefaction were not essential in the purification of sewage.

The author said he was prepared to admit that preliminary treatment in tanks of some kind or other might under certain conditions be desirable. That did not controvert the proposition that aerobic conditions were best to work under whenever possible

because the whole object of the tanks ought to be to take out the matters in suspension, leaving the filters or land to deal with matters in solution. It did not appear to him to matter very much whether they had 10 per cent. more or less of sludge to deal with. It was not worth risking the practical certainty of blocking up the filters by resolving (as it was called) the solids in the tanks and breaking them up into a state of more or less fine suspension and sending them over into the filters. It was far more expensive to clean the filters than it was to clear out the tanks. The author pointed out that it was important to secure a uniform rate of flow through the tanks over their whole area. He thought that that statement ought to be qualified by pointing out that it particularly referred to rectangular tanks in which the flow was from one end to the other. When they had deep tanks, either conoidal or pyramidal or circular tanks, they got an upward flow over the whole area and it was not nearly so important to take it off by means of a weir at the top. He had thought that it was very desirable to take the effluent away by means of a circular weir so as to give as great a length as possible for the effluent to flow over, but he had had difficulties with this and he found that by taking away the effluent through a single pipe a few feet below the top of the tank he got a much better result.

The author referred to contact beds under the heading of filters, but to his mind they were quite distinct. He thought that they ought to look at percolating filters and contact beds as separate types of apparatus altogether.

One of the great difficulties with contact beds was their filling and emptying in the limited time available. It was not difficult on a small scale, but on a large scale it was very difficult. He did not agree with the author's suggestion of having a space under the floor of the contact bed in the same way as they had a space under the floor of a percolating filter, except in the case of fine contact beds when filled from the top. In that case it did not matter, because the liquid contained in the bed was forced downwards by the incoming sewage from the top and found its way into the open space underneath the contact material, and no trouble was found with it as it had already been purified by percolation or during the period of aeration in the bed. In a coarse bed or one not filled from the top, a large open space at the bottom under an artificial floor was, he thought, a bad thing, because the space was filled with sewage which rushed down through the coarse material or was filled in from the bottom and did not receive treatment by contact with anything except the floor at the bottom or the false floor above it. The result was that the first rush of effluent from the contact bed when it was let off was practically unpurified sewage.

With regard to the depth of the filter, the author pointed out

that within certain limits it was generally found that the same quantity of sewage could be satisfactorily treated per cubic yard of material, whether it was in the form of a shallow or of a deep filter. Of course that depended on what was meant by "shallow" and "deep." They ought to have some more accurate classification than that. He knew of some filters about 18 inches deep and they were not satisfactory. Others were 8 to 9 feet deep and there was a vast deal of difference. With fine material the filter could be made a great deal shallower than it could with coarse material, because the whole thing depended on the area of material available for the sewage to flow over in thin films, as the author very properly described it. That area varied as the square of the diameter of the pieces of material of which the filter was composed. He had made some experiments on the purification effected at different depths in a filter dealing with about 10,000 gallons a day equally distributed over the whole area. The filter was divided and each section filled with material of a different size. From analyses of the effluents from different depths in each section it appeared that generally speaking the top 4 feet in a fine filter did the greater part of the work, but with a coarse filter—that is to say with material anything over an inch and a half—they got no good result before a depth of 6 feet was reached.

One word with regard to humus tanks. Sand filters were undoubtedly efficient but they required scraping and cost a good deal of money to keep in order. He found that if humus tanks were properly constructed they could remove the greater part of the suspended matters without very much trouble or expense, and he liked them a good deal better than filters. He had found it satisfactory to have a humus tank between the coarse filter and the fine filter and to put the effluent through the coarse filter and then through the humus tank, thus taking out the suspended matter. In that way the effluent from the fine filter could go right away to the river.

Mr. W. Fairley said that he was aware of Mr. Easdale's extensive knowledge of the subject dealt with in the paper, which, however, did not go into detail with regard to the various departments of sewage purification, but was full of practical hints.

The title of the paper "Sewage Disposal Ideals" was rather a taking one, because one's ideal in sewage disposal depended very much on the personal connection with the subject. He supposed that ideal sewage disposal works from the point of view of the River Authority would be works from which the effluent was always satisfactory; that the Local Government Board's ideal would be works which strictly fulfilled all the conditions of the Sewage Commission's Report; whereas the ideal sewage disposal works of those persons who for their sins had daily to look after them were works in which there was ample plant with no visible

effluent. He knew some places which were in that delightful position and he had always looked upon them as 'ideal' works.

With regard to general principles, Mr. Easdale had said that works should be arranged in such a manner as to prevent the creation of any nuisance at the lowest possible cost. They would all agree with that. It should be kept in mind, however, that works were primarily to prevent the creation of a nuisance, and he did not altogether follow his friend Mr. Lowcock on the question of standards, because standards were very varying things. He agreed with the author as to the baneful effect of competitions, but did not suppose that anything could be done to prevent them. It was very often suggested that competitions gave the opportunity for the young man to come forward and show what he could do, but he did not believe that was actually the case. It was impossible for an engineer to go properly into the details of a scheme within the short time which was usually allowed for completing the plans.

As regards pumping, his own experience was that it was not a matter over which they had any great control. A scheme must be either a pumping scheme or a gravitation one, according to the local conditions, and engineers had to accept those conditions.

Something was said with regard to the difference between contact filters and percolating filters, and most of it was in agreement with his (Mr. Fairley's) own experience. If a contact filter was properly designed, it would do its work efficiently. Besides this, a contact bed could be constructed so as to void the humus quite as well as a percolating bed would. For a few years past contact beds had been rather out of fashion, and a greater amount of ingenuity had been brought to bear upon the details of the percolating filters than upon the details of contact beds. He thought that each had a place. In some cases he should put down percolating filters and in others contact beds. The Sewage Commission in their Report pointed out that it was very difficult to work percolating filters fed with a septic effluent, without causing a certain amount of nuisance from smell. He had a feeling against the risk of putting down works which would give rise to anything like a nuisance in a residential district. Wherever they had percolating filters with a septic effluent, the plague of flies was also very serious. It was known that at the present moment medical men ascribed the carriage of the germs of many diseases to the action of flies, and it did seem insanitary to put up an erection which would be a breeding ground for what might be called vessels for conveying germs of infection from one place to another.

With regard to the question of false floors in contact beds, he agreed with Mr. Lowcock, rather than with Mr. Easdale. He said this not on account of any theory, but from actual experi-

ence. He knew of cases in which large contact beds were made many years ago with false floors over the whole area, and those floors had proved a failure. Possibly such floors may have been successful in other instances, but his own practice had always been to put in ample arterial drainage.

Mr. R. O. Wynne Roberts tendered to Mr. Easdale his congratulations for the excellent paper which he had given. The question of ideals was, in his opinion, not only one of person and place, but also a question of time. Carlyle said in one of his writings that ideals would live for a period, and then die. It was so with sewage disposal. Twenty years ago land treatment and downward intermittent filtration were the fashion of the day, but they were by this time more or less superseded by septic tanks and other forms of treatment. He did not say for a moment that land treatment had disappeared; but what he wanted to point out was that the ideals of twenty years ago were not what were regarded as the best thing at the present moment. During the last twenty years enormous sums of money had been spent by various authorities in the country on sewage disposal works with varying success, and he thought that they would agree that that was inevitable for every new process, and especially one for the disposal of sewage, must necessarily entail a loss of time and an expenditure of money before the right line had been reached. They hoped that in time, by the combined efforts of chemists, bacteriologists, and engineers, they would find a satisfactory solution.

The points raised in the paper were excellent ones, and with most of them he heartily agreed. He had taken a very great interest in contact beds for many years, but at present percolating filters seemed to be more fashionable throughout the country, as they were more or less adopted everywhere; yet he believed that contact beds had their functions to fulfil, and would under proper conditions fulfil them as effectually as percolating filters. It was undoubtedly quite a question of the arrangements and requirements of the locality. No one solution could be applied to every kind of sewage. As Mr. Easdale had said in his paper, they must design the works according to the nature of the sewage and of the locality in which the works were situated. Sometimes the contour of the land would not permit percolating filters to be installed, and, therefore, the engineer had to fall back on contact beds.

As to pumping, it was, in his opinion, impossible to avoid it in some instances. He had known cases where large sewers had been laid down, or at least were intended to be laid down in a flat district for the purpose of conveying a small quantity of sewage. The idea that evidently prevailed in the minds of those who designed the work was that less fall was necessary for a large

sewer, and thus the pumping might be minimized, but the effect would have been to convert the sewer into an elongated septic tank, which would ultimately give rise to a nuisance. Therefore, in a case of that kind, they had to put a sewer of suitable size to carry the sewage, and that would entail a steeper gradient, and also more pumping. There were many instances in the country in which, by careful selection of the land for outfall works, means would be found to reduce and even to avoid pumping.

Mr. A. G. Drury, referring to the question of sludge disposal, said that he understood the author to say in his paper that he had not dealt with the disposal of sludge, one reason being that he considered it more a matter for management than one appertaining to construction. He did not altogether agree with the author in that view. He thought that a cut and dried arrangement for dealing with sludge should be a part of every scheme, and it ought not to be left to the management to do the best they could with the sludge when the scheme was handed over to them.

He very cordially agreed with what the author had said with reference to the baleful influence of competitions. Competitive schemes, as had been pointed out, were invariably prepared very hurriedly. They were, in most cases, also drawn up at the expense of the competitors, and, therefore, as little time as possible was spent upon the work. Another thing was that district councils and authorities seldom called in an Assessor or Judge. They usually appointed themselves as judges and picked out the scheme which would cost the least.

Mr. Henry C. Adams said that the paper contained many points for discussion. In dealing with the question of cost, the author had said that the ideal was to give the engineer a free hand, and not to mind about the cost. But that, of course, was only an ideal. Engineers must be practical in their ideals, and the borrowing powers of the various local authorities were limited. Sewage works were generally put off as long as possible, and when the time came for constructing them there was not sufficient money available to secure first-class works. The only alternative, of course, was to get an Act of Parliament, and that was very expensive. If an ideal was wanted, he should say that it was to get the maximum of efficiency with the minimum of cost. He thought that what made a client shy of calling in outside engineers was the costly and wasteful way in which some works were constructed.

He did not quite see the point of the sentence in which Mr. Easdale spoke of the futility of engaging experts; but he knew that in many cases district authorities preferred that the works should be designed by their permanent officials, because they got them constructed more cheaply even if they were not so efficient in working.

As to competitions, he had not a very intimate knowledge with regard to them, but he could call to mind one competition scheme in which the whole of the pumping was designed to be done by a windmill without any auxiliary power at all. In another case, that of a seaside town in which he had happened to spend a holiday, he found that a prize had been awarded to a competitor, but fortunately the work had not yet been carried out. This competitor had been articled in a municipal office, and soon after he had turned twenty he gave up his engagement for some reason and turned his attention to piano tuning, and then some years later he prepared the competition scheme, which was selected because it was the cheapest. He (Mr. Adams) had been told that the competitor in this case had put down eighteenpence a cubic yard for excavating rock about eight feet deep. There were also absurdities in the design of the scheme. He (Mr. Adams) enquired why the local board accepted a scheme of this sort, which the Local Government Board would not approve, and the answer was that they thought that the engineer was "a very good sort" because he tried to save the ratepayers' money, and "if the Local Government Board did not agree with it—well, they ought to do so."

He did not agree with what Mr. Easdale said about pumping. First of all as to the increase of area to be dealt with by pumping. The greater the area the greater the liability of heavy storms, and in proportion the greater the amount of plant standing idle. Therefore the cost was not increased in proportion to the area, but in a considerably greater proportion. It was a somewhat difficult matter to put into figures the actual extra cost involved in increasing the pumping plant, but judging from the figures which he had of a plant to deal with a million gallons a day, it appeared roughly that if instead of providing for a million gallons a day they had provided for half a million, they might have saved £4,000, which would require about £200 a year for repayment of capital and interest. But taking the cost of pumping at £1 per million gallons, this half-million gallons would only cost about £180 a year to lift. The cost of pumping would therefore be slightly less than the capital cost; but if, in addition to that, they included the loan charges, repairs, wages, stores, oil, and other matters, it would, he thought, come out that the standing charges were three or four times as much as the actual cost of lifting. Personally, he always tried to keep the quantity of water to be pumped as low as possible.

He was very surprised to find that in dealing with ideals, Mr. Easdale had not referred to stand-by tanks. There were not very many of them at present in the country, but there was very great scope for the consideration of ideals in the use of them. It was obvious that after every storm, when they were filled up, or partly filled up, there would be the solid matter to clear out from

the bottom of the tanks ; it could not be left to accumulate because when the water was drawn off and the mud was drying, offensive odours would be given off. They needed considerable attention, and there existed a great opportunity for somebody to bring out an automatic valve for suitably controlling the action of the tanks.

Mr. P. G. Lloyd referred to a point mentioned on page 52 of the paper. The author there said :—" Within certain limits it is generally found that the same quantity of sewage can be satisfactorily treated per cubic yard of material, whether it is in the form of a shallow or of a deep filter." He believed that the Royal Commission came to the same conclusion, but it struck him that it did not exactly apply, and he would tell them why. Might he, for argument's sake, assume that they dealt with 150 gallons per cubic yard per twenty-four hours on a percolating filter 3 feet deep. All practical men knew that one of the greatest difficulties with which they had to contend in percolating filters for about six months of the year was a fungoid growth. He would say without much fear of contradiction that with 150 gallons per cubic yard on to a percolating filter they could keep the surface in a fairly good condition, but should that filter be six feet deep instead of three, and they wanted to deal with 300 gallons per twenty-four hours, on the same superficial area, the difficulties of the surface would be so much accentuated that they would constantly have to throw the bed out of work, in order to rake over and oxidise and kill the fungoid growth on the surface.

He had worked with both contact beds and percolating filters and quite agreed with most of the speakers as to the design of contact beds. He had found that with percolating filters he was able to deal with the variations of the flow of sewage better than he could on the contact system. That applied especially to pumping plants when they had to put on a second or third pump in the case of storms, perhaps for a couple of hours, during which contact beds were not so convenient for dealing with the increased flow. A percolating filter could also be worked very hard for three or four hours during the day, if necessary, when the maximum flow was on. Then when the flow settled down again it would automatically adjust itself to the 150 gallons per cubic yard per twenty-four hours rate. He had found percolating beds most efficient.

Mr. C. T. Walrond said that he knew that years ago competitions were very unfairly carried out. One good point about them, however, was that they were most excellent practice for the young engineer. In an office the chiefs might have had the widest experience possible, but the assistant did not have everything thrown upon him as he did in a competition where he had to do everything from beginning to end. He was never successful

in a competition on sewage disposal works, but he obtained a premium for a waterworks scheme. The job of constructing was not given to him, for the authority in its wisdom had decided as the basis of the competition that the water was to be obtained from a certain spring, but the Local Government Board considered the spring liable to contamination and would not allow it to be used. In one competition that he went in for, a member of the town council invited a pupil down and said, "We want land treatment; now, here is the land to which the sewage must be brought; this is the only place. Prepare a scheme on these lines and I will back you up." The prize was awarded to that man under the impression amongst some members of the council that the scheme was his (the speaker's) own. The pupil, being merely a pupil, was not able to carry out the scheme, and it was found eventually that the land on which the sewage was proposed to be treated was about the heaviest clay land in England. One of the members of the council said afterwards, "It seems to me that we have awarded the premium to a man who advised an unworkable scheme." Many instances of unfairness in competitions, intentional and otherwise, could be given.

Mr. H. C. H. Shenion said that it always seemed to him that the Local Government Board would do well to reconsider their demands for grit chambers in small village schemes dealing with flows up to say 30 or 40 thousand gallons per day. He had seen many grit chambers at small works, but he could call to mind no instance in which they had fulfilled their purpose. They always acted as receptacles for organic sludge, and he had never known them act as receptacles for grit unless the grit was so much mixed with ordinary sludge that it was quite indistinguishable from it. Although grit chambers were very useful in larger works where they had to deal with great quantities of sand coming down, it was a mistake to put them in on small schemes where there was frequently no grit to intercept, but engineers were forced by the Local Government Board to do so.

He should like to endorse the author's remarks with regard to screens because it always appeared to him that there was a large amount of solid matter retained on the screens which was a nuisance and practically speaking would make no difference to the works if it were not intercepted. In the case of a large town where such things as tin cans and old boots found their way into the sewer was needed, but for small schemes a screen was generally not required.

With reference to the contact beds, he was very much interested in what Mr. Fairley had said to the effect that the contact bed would void its humus quite as well as a percolating filter. That, at any rate, had been his own experience in one special case of a bed which was filled with broken flints. The

bed was overworked. It had been filled several times a day, and was clogged up with very foul sewage and had lost more than half its capacity. He then had the flow changed so that the bed filled only once a day. He found when he tested the bed, after two years working at one filling a day without any sort of cleaning, that it had entirely cleared itself and had rather more than its theoretical liquid capacity, which was 33 per cent. He thought that this clearly proved that a contact bed properly drained would discharge its humus and keep clear, provided that it was not overworked. The bed which he mentioned was dealing with a very strong septic tank effluent. The tank was never emptied and it contained a very large amount of sludge matter. He took it that the bed acted very much like a Dibdin slate bed.

With regard to false bottoms to contact beds, he had made them at four different places which had been working for some years, and found that they answered very well. He thought that a little reflection would show that there was nothing worse in leaving a two-inch space or less on the floor of a contact bed than in leaving spaces between layers of slate in a slate bed. He thought that frequently it was not desirable to get a very high degree of purification from the first contact bed. He found it better to distribute the work of purification over the second, and if necessary the third contact bed.

There was one ideal which did not seem to be mentioned in the paper with regard to sewage disposal, but which ought to be mentioned and that was sterilisation. The idea was not in favour in this country at present and in many places it was quite unnecessary to sterilise the sewage, but he thought that when they were speaking of ideals they should remember that in America sterilisation had been carried out on a large scale at Boston, Baltimore and elsewhere at a very reasonable cost. Even with treatment of four parts of available chlorine per million, the cost was something like 5s. per million gallons of sewage effluent treated. For the protection of water supplies and shell-fish layings, the process of sterilisation should not be overlooked.

Mr. A. Gladwell, speaking of screens and grit chambers, said that he was one of those much maligned individuals, permanent officials, and he had been called upon to expend his energies in the direction of designing and carrying out small schemes, but he had never found it necessary to have a screen. He quite agreed that in small installations a considerable amount of unjustifiable expense and labour was incurred in clearing the screens.

He had adopted the system of having small grit chambers with sharply sloping floors so that the contents could be very easily valved off. He had multiplied the number of grit chambers to three or four and fitted them with valves so that they could be cleared periodically and often. He very strongly believed

that the frequent easing of the contents of both grit chambers or what might be called detritus chambers and septic tanks was better than a less frequent emptying. He believed that a little attention to these matters went a long way towards a solution of the sludge difficulty.

He had not designed contact beds, but he was perfectly certain that both the contact bed and the percolating filter had their uses according to the requirements of particular cases.

He thought that there was great value in the suggestion made by one of the speakers with regard to interposing a humus tank between two sets of filters. That certainly appealed to him as a very wise and practical suggestion. One did not associate very much nuisance as a rule with humus, but he thought that it was better voided from the beds and arrested at as early a stage as possible.

Mr. L. A. Dibdin considered that the selection of the site should take place after the choice of a method of purification, as the existence or otherwise of nuisance arising from the process chosen must influence the choice of site.

He noticed with great surprise that the author included Dibdin's slate bed under the heading of "Tanks," and was glad of the opportunity to protest against this misnomer. There was no similarity between a slate bed and any of the known tanks, either in appearance, method of working or in the action taking place, beyond the fact that both had liquid entering and leaving them. Even this happened in a different manner. A slate bed was a contact biological bed with filling material of slate slabs instead of clinker, gravel, etc., and did more than merely arrest solids in suspension, causing the arrested solids to be inoffensively and aerobically broken down by the biological life existing in the bed. The slate bed effluent being aerobic was more suitable for further purification on fine contact beds or continuous filters than the effluent from anaerobic tanks, especially as air was trapped under each slate each time the bed was filled.

The author stated that if the greater portion of the work was thrown on the tank the sludge problem was intensified. Mr. Dibdin agreed, but pointed out that this showed the enormous difference between slate beds and tanks, as although as much as possible of the work was thrown upon slate beds, yet the sludge problem was not intensified but became non-existent. The author referred to the contention of some that it had been shown possible to purify sewage under entirely aerobic conditions. It had not only been shown to be possible, but was continually and economically being done, as the author and many other engineers were aware. As the author stated that where it is absolutely essential to prevent the slightest smell, Dibdin's

slate beds might be adopted, and in another place that the cost must be subsidiary to the prevention of nuisance, it was obvious that slate beds followed by secondary aerobic treatment should be chosen in preference to any sludge-producing tank treatment, irrespective of the fact that the former was not so expensive in initial cost and maintenance. Slate beds followed by suitable secondary treatment therefore approached most nearly to the ideal given by the author even if they did not accomplish it.

In comparing the working capacity of contact beds with that of percolating filters it must be remembered that filters being almost always considerably deeper than contact beds, had a much smaller area per cubic yard, and consequently, in times of storm, weak effluent from primary treatment might be safely streamed through the contact bed at a far greater rate than it could be passed through the filters, and was not by any means limited to a quantity equal to a total of six fillings per day. It appeared obvious that an equal quantity of similar cultivated medium will treat an equal quantity of similar effluent, and the author seemed to confirm this in his remarks on the depth of percolating filters. The choice between contact beds and filters, therefore, should be decided by considerations of the risk of smell caused by discharging primary effluent on to the medium, together with the initial cost and expenses of upkeep. It would generally be found that the choice was in favour of contact beds, which had the additional advantage that they required less fall. In the majority of cases, contact beds need not be absolutely watertight, and to make them so was to waste money. It made no difference to the treatment or to the action of micro-organisms if some liquid escaped through the containing walls. Beds on clay sites would generally be watertight, and on gravel sites if some of the effluent found its way to the subsoil or through partition walls, no harm could be done. Contact beds formed merely by excavating on clay sites had been approved by the Local Government Board, and with slate contact beds it was only necessary to line the batters and floors with slate slabs, a method now being adopted by the War Office at the Curragh Camp works.

Mr. C. Chambers Smith said that few men had had a wider experience of the successes and failures of sewage disposal works than had Mr. Easdale, with most of whose remarks he very cordially agreed.

With regard to competitions, it was a mistake for engineers who had little practical experience to enter into competitions for the design and construction of sewage disposal works. Only those who had a lengthy experience knew how many pitfalls there were to be encountered in the carrying out of schemes and in the subsequent management of disposal works.

On the question of purification Mr. Easdale very properly

pointed out that what would answer for one place would not answer satisfactorily for another. The sewage from a town which had purely domestic sewage might be treated with very little difficulty, but where they had sewage which contained the wastes from a considerable number of laundries and breweries they must treat it in a very different fashion.

The author was quite right in saying that, where one had sedimentary tanks, screens were unnecessary. He had designed rotary automatic screens which answered very well indeed, and removed a considerable amount of paper, fæces and so forth. But if that matter was allowed to go into the tanks it would be removed by the action of the tanks themselves, and only in cases where they had pumping he should advise the use of screens at all. One very common mistake with regard to the design of the tanks was that no provision whatever was made for the emptying of the sludge from the tanks. It was most important that provision should be made for emptying the sludge automatically if possible. This was not at all difficult, and it was a matter which required very careful consideration in designing.

On the question of contact beds and false floors he quite agreed with Mr. Easdale. One of the causes of failure of contact beds was that there was insufficient drainage in the floors and insufficient slope, hence the humus matter was not drawn away. In percolating filters it was drawn away much more quickly.

With regard to contact beds he had perhaps more experience than most engineers in the country, he having put down in 1906 the first double contact beds in England. He had found with regard to capital cost of construction that taking a constant in gallons the cost of percolating filters was £6 and of contact beds £14 per thousand gallons.

He had put down percolating filters at a depth of 4ft. but he could not put down contact beds to treat a sewage effluent satisfactorily at a depth of 4ft. That was the only point on which he did not agree with Mr. Easdale in the whole of the paper.

With regard to fine and coarse material he quite agreed that they must not mix coarse with fine material.

Humus tanks were, as Mr. Easdale pointed out, absolutely necessary in any circumstances, and it was quite clear to anyone who had eyes to see that the difference between the effluent coming into the humus tank and that going out of it was very marked.

With regard to the cost of works he did not believe in spending twopence where a penny would do, but he did believe in efficiency.

For an ideal system where a sewage disposal site was to be near dwellings or public highways, he had come to the opinion that this should comprise slate beds—in lieu of sedimentation or septic tanks—the effluent from such slate beds being purified

on filters or contact beds. Such an installation would be free from nuisance, and the purification would be carried out entirely on all-aerobic lines, and at slight cost.

Mr. R. Aglio Dibdin wrote :—

The choice of the system of sewage disposal is a matter for the chemist and biologist. When an engineer has to select between systems advocated by different chemists he should himself enquire into the reason and common sense underlying the various chemists' selections. In this way, chemistry and engineering overlap one another, and that the two branches of science should be utilised with the minimum of friction so as to supplement one another most efficiently is an ideal in sewage disposal. A free hand to all individuals of any profession is opening the door of possible abuse, and no engineer should object to criticism of his scheme, as he can always substantiate his position by shewing how he arrives at his result.

In the matter of competitions the fact that these are sometimes carried on in an improper manner is matter suggesting the reform of the conditions of competition, not the abolition of competitions themselves. The suggestion that wide experience is a fundamental qualification to an engineer is only true if it be accompanied by a wide training in observation and exercise of judgment. Experience without judgment is the commonest cause of bigotry and conservatism.

In selecting a process to deal with peculiar waste matters the tastes of micro-organisms should be consulted before the opinions of brother engineers. From the single organism under the microscope one can and does habitually predict what will happen to a million tons of matter. In special cases of extraordinary waste matters the biologist should be consulted. The author expresses opinion that septic action is not essential. The Royal Commission have proved the truth of that opinion. It is extraordinary to notice that in spite of the general agreement that prevailed in the discussion on this point, a large amount of time both in the paper and in the speeches was devoted to the consideration of ideals for apparatus and methods of working relating to the use of septic or other "hydrolytic" tanks. Anything relating to processes which are not essential can hardly be considered worth the attention of the practical engineer.

It should be pointed out that the word hydrolysis is used to express something that it does not mean. Hydrolysis in chemistry means a loosening of particles by the introduction of a molecule of water. It has been used as a pleasant alternative for a tendency to putrefactive liquefaction. We know quite well that putrefaction does not result in liquefaction, but the partial change that does take place under septic action has been called hydrolysis. The persistent use of this word by engineers in this

connection is a blunder. Its original introduction was a philosophical sin.

In reference to contact beds and filters the author is of opinion that contact beds may be adopted with advantage under certain conditions. It would be interesting to know of some detailed instances when they ought not to be adopted. With regard to the periods of filling and emptying beds the times may be increased or decreased from the period given by the author according to the degree of dilution of the effluent. One microbe can deal with a certain amount of solid matter per diem. A million microbes under healthy conditions can deal with a million times as much. The presence of more or less water with the food supply of the organism will not affect their digestion, as they do not commence serious work on matters in solution until they have been removed from the effluent by the mechanical action of the filter or contact bed. The degree of concentration of organisms in a bed and the convenience with which their food is supplied to them determine the amount of work a unit bed can do, and this is biologically true of a unit of bed whether in a continuous filter or a contact bed. The author states that the essence of the treatment in percolating filters is the slow passage of the liquid in a thin film over the filtered material. As a matter of fact the essential principle is the removal of the oxydisable substances from the liquid by the surface molecular attraction of the filter material, and their exposure to air so that the organisms can attack them. Naturally, the slower the passage of the liquid and the thinner the film, the greater will be the effect of mechanical attraction and the less will be the risk of the organisms having more work than they can manage or less air than they need. As to the contention that no engineer should attempt to design or carry out works without long continued practical experience of existing works, the reply is obvious that if an engineer can observe, investigate, and reason upon one set of data he can observe and investigate the necessary data for carrying out any other branch of reasoning, and that an engineer is expert in design of any kind is evidence that he could be expert in another kind of design, and it is possible that a man with no experience to start with, but a catholic appreciation of the unity of scientific laws, and an ability to utilise results of his own and other people's investigations, would design and construct a sewage works at least as useful as if not better than many engineers who have no experience outside existing installations, and who possibly lack the insight of the other man.

Mr. Easdale communicated the following reply to the discussion :—

In the first place I plead guilty to the charge preferred by Dr. Gilbert Fowler. It was quite an oversight on my part, and as

proof that it was not intentional, I may say that I have already publicly expressed in writing the opinion that the engineer should obtain the assistance of the chemist and the biologist in matters connected with sewage disposal. Where the sewage is of an exceptional character, and especially where the treatment of trade wastes is involved, I consider the collaboration of all three is essential.

It is a source of considerable gratification to me that with one or two exceptions the speakers who took part in the discussion have all had practical experience in sewage disposal, and that they were able to support my views to a very large extent. There are, however, one or two points mentioned upon which I should like to comment briefly.

Having regard to Mr. A. J. Martin's extremely kind but quite undeserved references to myself, and his genial and captivating powers of argument, I hesitate to cross swords with him. On second thoughts, however, I remember that, for this occasion, at any rate, I have the last word, and he cannot hit back. I am therefore emboldened to reply to his criticism of my statement that three fillings per day of diluted sewage is the utmost that a contact bed can satisfactorily treat in wet weather. I am prepared to admit that Mr. Martin himself would have no difficulty in dealing with dilute septic tank effluents at the rate of five fillings per day; but there is only one Mr. Martin, to many hundreds of contact beds, and it is the absence in the majority of cases of proper direction and supervision of management such as he could give which accounts for most of the failures. Further, I have frequently found cases where men, having heard or read of "3 fillings per day for contact beds," have applied this rule to the dry-weather flow with disastrous results. I can imagine such a man, say, the surveyor of "X-cum-Z," reading Mr. Martin's statement with great satisfaction, as he is just about to prepare a scheme of sewage disposal for the village of "Y." He immediately says to himself: "Our sewers will be on the separate system, so we shall never have more than twice the dry-weather flow, and the gross capacity in cubic feet of the beds I

shall require will thus be $\frac{2 \text{ D.W.F.} \times 3}{5 \times 6\frac{1}{4}}$ The sequel will be seen in about two years' time (if not before), when the annual report of the Medical Officer of Health will contain a statement to the effect that "contact beds are dead," and the technical journals will report that the Council of "X-cum-Z" have decided to convert their existing works at the village of "Y" into percolating filters. Bearing these things in mind, I felt it desirable to avoid making any statement of particular cases which might unwittingly be accepted as of general application, and to maintain that one filling per day in dry weather, and three fillings per day in wet weather, is the utmost that contact beds

should be allowed to treat. One speaker suggested that large volumes of dilute sewage in times of storm may be satisfactorily treated in contact beds by allowing the liquid to "stream" through them, but I cannot agree with him. On the one hand, the material will not receive the proper period of rest, while standing empty, for aeration and oxidation which is essential to its efficiency in dealing with the ordinary flow, and, on the other hand, these liquids are liable to contain a considerable amount of inorganic matter, such as fine sand and earth, in suspension, which is not decomposed by the processes which take place in the bed, and can only be removed by taking out the material and washing it.

I am pleased to find that an engineer and a chemist with such long and wide experience of contact beds as Mr. Martin and Dr. Fowler agree with my suggestions for the construction of contact beds. With regard to Mr. Fairley's statement of a case where a false floor in a contact bed was found to be unsatisfactory, I think the open space above the floor must have been excessive. My own idea is that it should not exceed $1\frac{1}{2}$ or 2 in. at the most. In any case, I assumed that double contact, if not triple contact, is adopted in all schemes. Further, I suggested false floors more particularly as a remedy for the choking which has been mentioned as the chief defect of contact beds. In percolating filters every facility is provided for the free exit of the "undigested residuum," and if this were not done they would rapidly choke. This applies with equal force to contact beds, and if false floors are not provided to allow the suspended matters to pass out in the effluent and be dealt with separately, no reasonable man can complain if the material becomes clogged and loses its liquid capacity and ultimately has to be removed, washed, and sifted before it can be used again. Even where the material is bad, and breaks down rapidly, it would not prove so unsatisfactory if a false floor were provided to permit the products of disintegration to pass out with the effluent instead of remaining to choke the material. In saying this I do not in any way go back on my recommendation that only the best material should be used in all cases.

I desire to thank Mr. Lowcock for the excellent manner in which he opened the discussion by contributing so much valuable information from the abundance of his own experience. His recommendation that the bottom of a fixed screen should be carried down well below the general floor level of the chamber is a strong point which I endeavoured to bring out in the paper, where I stated that one of the usual defects of screens is "lack of depth below the water level." My reference to the necessity of securing a uniform rate of flow through tanks referred particularly to rectangular tanks, as the majority of tanks in use are of this type, and it is in these that uneven distribution of the

flow is chiefly found. Mr. Lowcock's experience of the best method of operating circular tanks is very interesting and valuable. In reply to his query as to what I meant by "shallow" filters, I ought to have stated that I do not consider it safe to use percolating filters with less than 4 ft. average depth of material, including the false floor or drainage tiles.

In reply to several speakers, who referred to the question of pumping, I certainly consider it essential where the sewers would otherwise have to be laid at gradients which would not give a self-cleansing velocity. Further, the principle I suggested that only that portion of the sewage which could not be delivered at the outfall by gravitation should be pumped, must be applied with discretion. For example, in a small scheme of, say, 50,000 gallons per day, dry weather flow, it might not be sound practice to allow one-half of the volume to gravitate if the other half has to be pumped, although it might be the right thing to do if the volume were ten times as large. Everything depends upon the circumstances.

I agree with Mr. H. C. Adams that the engineer must of necessity take into consideration the borrowing powers of an authority by whom he is employed to design a scheme of sewage disposal, but if they are not sufficient to cover the cost of the work on the lines which he considers essential to secure efficiency, I think the proper course to adopt would be to advise the authority to carry out only so much of the scheme as their funds will permit, rather than to cut down the cost of the whole scheme at the risk of loss of efficiency. The point I wished to make was that when the question of low cost is placed first it usually means cutting down the size of the tanks and filters and the thickness of walls and floors to the minimum, accepting material of poor quality for the filters, low-grade pipes, cheap and nasty cement, dirty sand and ballast, soft bricks, omitting concrete under pipes, and all provision for properly testing the sewers, with the certain result that sooner or later the tanks leak, the filters are clogged and require new material or additional filters, the sewers leak, and the pumps cannot cope with the volume to be raised, so that additional plant is required, or at any rate, the cost of pumping is two or three times what it ought to be. It is obvious that the expense of remedying defects of this kind will bring the ultimate cost of the scheme up to a sum much in excess of that which would have been necessary if the work had been done properly at first. Another point is that even when a faulty scheme has been made good it is only a patched-up job, and can never be so satisfactory in operation as if it had been perfect originally. I feel very strongly that true economy consists in placing efficiency first and above all other considerations.

I have to admit the omission of all reference to storm-water treatment and stand-by tanks, but this was due to limits of

space. Further, although experience has shown that the old type of storm water filter is totally ineffective, the new method of treatment in stand-by tanks has not been in vogue long enough to permit of any practical experiments as to its merits. I quite agree with Mr. H. C. Adams that if the tanks are to be effective they must be emptied after every storm, or at any rate the next morning after every day during which they received any discharge, however small, from the storm overflow. Personally, I think it might meet all requirements if it were made a rule that stand-by tanks must in any circumstances be emptied of their liquid contents, however small, every morning without fail, and the sludge deposited on the bottom removed at the same time. There is nothing in the recommendations of the Royal Commission, so far as I can gather, to indicate that the liquid contents of these tanks shall receive any special treatment, and it might be inferred that the contents may be discharged into a stream in the same manner as the overflow after they are full. I should, however, hesitate to adopt this course myself, as there would be great risk of the sludge being discharged at the same time, either intentionally or by mistake, and the purpose of the tanks would be rendered nugatory.

I think it will be found necessary to make special provision for running off the supernatant liquid from these tanks separately, and treating on land or on a rough filter before discharge to the stream, or, better still, to return it to the screen chamber or detritus tanks to mix with the ordinary sewage. The sludge should be drawn off and disposed of with the rest of the sludge from the detritus tanks and sedimentation tanks.

Mr. Gladwell has evidently been making practical investigations into the workings of detritus tanks. His experience coincides with my own, and I am glad to find that in preparing drawings some weeks ago of model types of tanks for illustrating a book on the subject, I have practically adopted his valuable suggestions.

I regret that I should have caused Mr. L. A. Dibdin any unhappiness in mentioning slate beds under the heading of "tanks." I wish I could say it was an oversight, but I should suffer continual prickings of conscience if I were to do so, for it was a wilful deed. In my opinion, it is only under very exceptional conditions that slate beds will be satisfactory without other means for further treatment of the effluent. On the other hand, I consider slate beds may, in many cases, form a very effective preliminary process of treatment when followed by contact beds, or percolating filters, or suitable land. I should also like to point out that in the opinion of the Royal Commission on Sewage Disposal quiescent sedimentation with chemical precipitation in tanks is the most efficient preliminary process which they have investigated, and I think I am correct in saying that they suggest two hours as the

period of settlement. Slate beds, as I understand them, not only comply with these conditions as to the period of quiescent settlement, but they offer the additional advantages that the matters in suspension are deposited in a number of thin layers on the slates instead of in one thick layer at the bottom; that no chemicals are required to assist in their deposition; that they undergo decomposition and reduction to a considerable extent under aerobic conditions, and thus there is very little possibility of nuisance arising from smell; that there is no necessity to clean out the beds as the "undigested residuum" passes out in the effluent and can be settled out and dried at very little expense for labour and no need for presses, and that as the settled effluent has not undergone any process of putrefaction it should be eminently suited for the subsequent stage of oxidation in filters or on land. From the foregoing it might be reasonable to assume that when the conditions are suitable for the installation of slate beds they may be accepted as ranking even above the most efficient preliminary process recommended by the Royal Commission, and in that position I trust that Mr. Dibdin will be satisfied to leave them in the category in which I have placed them. It is unfortunate that in another matter I am also at issue with Mr. Dibdin. He expressed the opinion that it is of small importance if contact beds are not absolutely watertight, and they may therefore consist of simple excavations in the ground. I cannot agree with this in any circumstances. If the beds leak it is impossible to work them properly, and if the leaks take place from one bed to another, as is usually the case, it is impossible to secure the proper periods of rest and aeration which are essential to the efficient working of the beds. Further, I do not think the Local Government Board will ever again sanction the construction of contact beds in mere excavations in the clay without the provision of substantial construction to render them perfectly watertight.

Mr. R. A. Dibdin's contribution to the discussion is an excellent illustration of the manner in which the scientist deals with practical problems. He argues that as one microbe can deal with a certain amount of organic matter, one million microbes can deal with a million times as much, regardless of the quantity of water in which it is contained. Theoretically this is correct, but in practice the engineer finds that he has to separate the organic matter from the water and that there are physical difficulties in accomplishing this beyond certain limits. This applies particularly to contact beds where the necessity of emptying them entirely and leaving them empty for certain minimum periods to allow for aeration and oxidation does not permit of their remaining in operation continuously for long periods. Lack of knowledge on this point has been one of the causes of failure in contact beds in the past, and in my opinion the greater facility, within certain limits, with which percolating

filters can be operated continuously for long periods when dealing with a dilute sewage represents the chief advantage they possess over contact beds.

My reply to Dr. Gilbert Fowler with regard to the necessity for co-operation between engineer, chemist and biologist will, I hope, also satisfy Mr. Dibdin.

April 4th, 1910.

DIOGO A. SYMONS, PRESIDENT,

IN THE CHAIR.

MOULMEIN WATERWORKS.

By PERCY G. SCOTT, A.M.INST.C.E.

[MEMBER.]

In presenting this paper on the Moulmein Waterworks, the author regrets that it is not as complete as he would have liked to make it, because he had no opportunity of visiting the works till they were completed. As regards the methods of construction, the information given is taken principally from specifications drawn up by Mr. E. G. Foy, Sanitary Engineer to the Burma Government, who was mainly responsible for the design of the works. The author, however, trusts that the paper, though not a very detailed one and prepared only from notes made by him on his visits to the works, may be of interest to those who are not familiar with the methods adopted in the construction of waterworks in a tropical country.

HISTORY.

Moulmein is one of the principal ports of Burma, situated on the river Salween, and has a population of about 60,000 people. During the fifteen years prior to the preparation and adoption of the Mayabyan Valley Gravitation Scheme, which is described in this paper, the wells of Moulmein, which formed the chief source of water supply, were adversely reported upon by the medical authorities, and during that time no fewer than five schemes were suggested to the Municipality for adoption. The schemes referred to are noted below in general terms :—

(1) Mr. Addis's scheme for collecting rain water from the roofs of the houses and storing it in small cisterns.

(2) Mr. Bayley's scheme for drawing water from the Attaran river at a point 12 miles from Moulmein (where it would be unaffected in quality by the sea-water), and pumping it to a reservoir near the town, whence it would be again pumped into cisterns conveniently situated on the hill for distribution by gravitation.

(3) A scheme suggested by the Municipality for the collection of rain water in reservoirs near the town, whence it would be distributed.

(4) Mr. Bayley's scheme for bringing the water from the Mudôn lakes some 20 miles distant, to supply the lower parts of the town.

(5) Captain Dodd's scheme to construct a series of reservoirs along the line of the lower main road, the water to be taken from the Salween river at low tide.

The first scheme was dismissed on account of its crudity. There was nothing to recommend it even from an economical point of view, for it would have cost quite as much as a more scientific scheme.

The second and fourth schemes were considered to be too costly to construct and maintain.

Captain Dodd's scheme was not further considered after the available water had been found on analysis to be unfit for drinking purposes; and the third scheme, suggested by the Municipality, then appeared to be the most suitable of all. This scheme was considered in greater detail, and the Taungwaing Valley was examined, but the levels showed that a gravitation scheme was impracticable; and in the beginning of 1898, Mr. E. G. Foy, Sanitary Engineer to the Burma Government, was deputed for special survey duty to work out the details of a suitable scheme. Mr. Foy designed a gravitation scheme with a dam to hold up water coming down the Mayabyan Valley. This scheme was examined by a committee of engineers who inspected the proposed site and made suggestions in accordance, with which the works were practically constructed. The scheme is described under the following heads and subheads.

SURVEY OBSERVATIONS.

At the end of February, 1898, the Moulmein Municipal Committee sanctioned the expenditure of Rs. 3,100 (about £207), and fieldwork was started early in March, 1898, being completed by the end of May of that year. The eastern boundary of the Taungzun hills was located by theodolite intersections, and a prismatic traverse taken along the ridges. Levels were taken at close intervals over the reservoir site to enable 5 feet contours to be plotted on the plan (Fig. 1) and calculations were made for the storage capacity of the reservoirs for every foot in height. The acreage of the catchment area was calculated by plotting the traverse taken along the ridge of the hill and the embankment enclosing the valley.

Samples of water supplying the reservoirs were examined by Mr. Matthew Hunter, M.A., F.C.S., Chemical Examiner to the Burma Government, and the results of his analysis are given below:—

	17th Aug., 1898.	3rd Oct., 1898.	10th Oct., 1898.	13th Oct., 1898.	11th Nov., 1898.	
Solids ..	2.8	3.4	3.4	2.0	2.8	} Grains per gallon.
Chlorine ..	0.4	0.3	0.3	0.4	0.4	
Free Ammonia	0.03	0.03	0.01	Nil (sic)	0.0025	} Parts per million.
Albuminoid Ammonia ..	0.09	0.04	0.02	0.04	0.09	

The water is of good quality and is fit for drinking purposes.

There are no records to show that the water was examined bacteriologically, but it may be stated that there is not a single building within the catchment area (which is carefully conserved), all people not connected with the works and animals being kept out. The water supply is free from sewage contamination. The samples were probably taken at the site of the reservoir, from the stream feeding the reservoir basin.

RESERVOIR AND ITS STORAGE CAPACITY.

Fig. 1 is a plan of the catchment area and reservoir (with positions of accessory works) of the Moulmein Waterworks. The whole of the catchment area is thickly wooded and is 400 acres in extent; the rainfall over this is assumed to be the same as that for the town of Moulmein, of which records exist. Owing, however, to the general elevation of the catchment area above the surrounding country it would seem that the rainfall intercepted by it would be more than that recorded in the town about $3\frac{1}{2}$ miles away. The quantity of rainfall, therefore, taken as a basis for calculating the storage capacity would err on the right side. The mean annual rainfall for 14 years from 1884 to 1897 was 185.36 inches. Mr. Leventhorpe in his report on the proposed Taungwaing Valley scheme gave the mean annual rainfall as 187.7 inches for a term of 44 years from 1850 to 1893. The average periods of wet and dry seasons as deduced from the rainfall statistics are 145 days and 220 days respectively. The minimum rainfall recorded was 124.24 inches in 1850. If Hawksley's formula ($C = \frac{1,000}{\sqrt{r}}$ where C = the number of days'

storage required, r = average rainfall in inches during three consecutive dry years, the average rainfall for a dry year being taken as five-sixths the average rainfall for a number of years) be used, the number of days' storage required for the Moulmein water supply will be 80. It is difficult to apply this formula for

differences due to irregularity of rainfall, though it is found to be approximately correct for England.

For calculating the flow off catchment areas, Dickens's formula, $D = C \sqrt[4]{M^3}$, or Ryves's formula, $D = C \sqrt[3]{M^2}$, where D = discharge in cubic feet per second, M = the area of catchment in square miles, and C = a coefficient, is generally used. Great care is required in applying these formulæ, as the coefficient may vary from 150 to 1,000, or even more in exceptional cases, and the safest way is to calculate the discharge by means of sections when the stream is flowing and the highest flood level can be ascertained. In some cases the coefficient can be found by comparison with the already ascertained discharge of catchment areas which are more or less similar to that under consideration. In the case of the catchment area supplying the Moulmein Reservoir, the method of calculating the flow off was to take one-third of the actual rainfall over the catchment area as the quantity flowing into the reservoir, the remaining two-thirds being assumed as the quantity lost by evaporation and absorption. This quantity on calculation is found to be 564 million gallons. But as the water in the reservoir is gradually increased month by month, the waterspread increases, and the absorption therefore becomes less and less, and, calculating on this basis, it was found that there would be 755 million gallons available for storage.

No doubt some experiments were made to arrive at the above method of calculating the storage capacity of the reservoir, either by gauging the stream supplying the reservoir at its site and comparing it with the rainfall or in some other way. When the works were visited by the author no observations were being taken of the evaporation, and it is not known what the actual yield is since completion of the work. The author was unable to obtain information as to the geological structure of the catchment area.

The reservoir has been designed to hold 648 million gallons, the storage capacities at various levels being given below:—

	Millions of cubic feet.
R.L. 131 (Weir Level) to R.L. 130	5.5
R.L. 130 to R.L. 125	25.5
R.L. 125 to R.L. 120	21.6
R.L. 120 to R.L. 115	17.4
R.L. 115 to R.L. 110	13.4
Below R.L. 110	20.2

Or 648 million gallons.

The letters R.L. indicate Reduced Level. The levels are reduced to the Great Trigonometrical Survey datum, *i.e.*, mean sea level at Karachi.

This quantity is more than ample to supply the town of Moulmein, as, allowing 24 gallons per head per day for a population of 60,000 people, the full quantity that will be consumed during the wet and dry seasons will be 209 and 317 million gallons, respectively, equivalent to a discharge of 1,000 gallons per minute or 1,440,000 gallons daily. Allowing for a loss of 21.6 million cubic ft. or 5 ft. average depth on account of evaporation and absorption per annum, the quantity required will be $50.5 + 21.6 = 72.1$ million cubic feet, or 16 ft. depth of water between 131.2 and 115 contours. The water level in the reservoir at the commencement of each year will be at R.L. 115, and this has been assumed as the lowest level of water in the reservoir for calculating the size of the delivery main.

Before the water was stored in the reservoir the catchment area was entirely cleared of trees and undergrowth, and the Kimmungeon Kyaung (monastery) was removed to a site outside the catchment area, compensation being paid for the removal. As the catchment area was Government land on which there was no cultivation, it was handed over to the municipality free of cost.

HEADWORKS.

These comprise the dam enclosing the reservoir, the outlet sluice and the waste weir. The dam consists of a puddle wall, selected earth and ordinary earth (see Figs. 2 and 3).

The puddle trench for the foundation of the puddle wall was dug along the axis of the dam to an average depth of about 12 ft. on the south of the lowest point of the dam, where it crosses the Mayabyan stream. On the north side of the stream the average depth of the puddle trench is 16 ft. The bottom of the trench is hard clay, with the exception of a width of about 100 ft. where it crosses the stream, which portion is sandstone rock. No geological sections or plan of the puddle trench are available, but from the various reports it would appear that the foundations were satisfactory. The puddle trench is 16 ft. wide at ground level, and has side slopes of 1 in 12. The material used for filling the puddle trench and building the puddle wall was the most retentive clay available, and could be got within a distance of 1 mile from the site of the dam. The clay used for the puddle was first kept in tanks, allowed to soak overnight and then pugged by men's feet into a smooth plastic mass. It was then carried to the site of the dam and again trodden by men. The puddle for the filling of the trench and the puddle wall was brought up in 6-inch layers, and each layer was thoroughly incorporated with the one next below it in order to form a homogeneous mass. The puddle wall is $5\frac{2}{3}$ ft. wide at top, with reverse side slopes of 1 in 12, which gives a width of 16 ft. at ground level. The top of the puddle wall is at R.L. 133, that is nearly 2 ft. above the crest of the waste weir. From recent

experiments made in the earthen portion of the Croton dam it appears that the hydraulic gradient through well compacted earth is 1 in 20, and referring to Fig. 3 it will be seen that the hydraulic gradient of the water passing through the water-side portion of the dam would fall about 2 ft. below the top of the puddle wall. The height of the puddle wall is, therefore, sufficient. The earth for the portion of the dam marked as selected earth and ordinary earth was obtained within a mile of the site of the dam, a tram line being used for carrying the materials. The earth for the embankment was spread in 6-inch layers, made to slope slightly inwards, and rolled with heavy rollers as is the usual practice in India. The embankment is about 3,750 ft. long with a top width of 15 ft., and side slopes of 3 to 1 on the water side and 2 to 1 on the rear side. At the gorge or river crossing where the dam is 68 ft. high, the rear portion of the dam (from R.L. 70 to R.L. 90) is constructed of dry masonry, built of dressed laterite blocks laid at a slope of 3 to 1, and resting on a concrete toe. This is done to prevent a tendency to slip, as the dam abuts on rapidly rising ground, and an arrangement of this kind helps to drain the rear portion of the embankment. The whole of the outside slope has been turfed, and the inner slope pitched with rubble stone, 1 ft. deep, to protect the surface against the action of waves.

It would seem that the puddle trench has not been carried deep enough, as is evidenced from the number of leaks at various places, the total leakage being 3 cub. ft. per sec. This leakage is probably due to the water under pressure finding its way under the bottom of the puddle in the puddle trench. As was anticipated, the work took two seasons to complete; a temporary weir 200 ft. long was therefore made at R.L. 105 for carrying away flood water during the rains.

Outlet Sluice.—On looking at the plan (Fig. 1) and section of the dam, it would seem that the best place for the outlet tunnel was clear of the dam. The outlet tunnel was probably built in the dam itself or rather under the dam for economical reasons, as though it was quite feasible to build the tunnel clear of the dam it would have been about 1,000 ft. long, and the finances of the Moulmein Municipality did not admit of any extra outlay. The outlet sluice as constructed consists of a circular well, 9 ft. internal diameter, built of brick in cement, on a cement concrete foundation 7 ft. thick, the depth of this well being 33 ft. The well is provided with three 16 in. diameter sluice valves with draw-off levels as follows:—

Lowest draw-off at R.L. 105.

Middle draw-off at R.L. 113.

Upper draw-off at R.L. 125.

In front of each inlet in the sluice chamber, screens of copper wire gauze set in wooden frames are provided to strain the water. The sluice chamber is connected with a brick in cement culvert

on a cement concrete foundation $1\frac{1}{2}$ ft. thick, through which the delivery main 16 inches in diameter is carried to a circular outlet valve chamber enclosing a 16 in. diam. sluice valve. The valve chamber is 21 ft. 6 ins. deep and 7 ft. $10\frac{1}{2}$ ins. internal diameter, built of brick in cement on 18 ins. of cement-concrete. The culvert is built just underneath the puddle trench. Fig. 4 is a section of the outlet sluice well and tunnel.

Waste Weir.—The position of the weir is shown in Fig. 1. It is a saddle weir cut out of natural ground, the top of the weir being 200 ft. long and faced for the entire width of 23 ft. with one layer of brick on edge in lime-mortar. At the reservoir end of the weir it is flanked at each end by two pillars of brickwork in lime-mortar, 2 ft. wide at top, and 2 ft. above the crest of the weir.

The level of crest of weir is nearly 7 ft. below the crest of the dam, and there is a fall of 1 in 100 from the crest down stream to facilitate the passage of flood-water. The weir level is calculated by assuming the maximum rainfall to be $5\frac{1}{2}$ ins. per hour, and supposing $\frac{1}{4}$ ins. were to run off in an hour the discharge over

the weir would be $\frac{43,560 \times 400}{60 \times 60 \times 3} = 1,610$ cubic feet per second,

and applying the formula $H = \sqrt[3]{\frac{W^2}{7B^2}}$ for a weir having a

clear overfall, where H = height of water in ft. above crest of weir, W = quantity of water in cubic ft. per second passing over the weir, B = breadth of weir in feet, the maximum overflow over the weir would be 2.1 feet. In this case however, there is not a clear overfall, but a small channel with a slope of 1 in 100, therefore the height of overflow will be rather less than 2 ft. It will be thus seen by comparing the crest of the dam with that of the weir that there will be a more than sufficient margin of safety.

SERVICE CISTERNS.

Service cisterns or tanks are used in order to utilise the full 24 hours' discharge through the delivery main and to store a day's supply in the town as a reserve in case of accidents on the main and for fire-extinguishing purposes.

There are three service cisterns, rectangular in plan, the sides sloping 1 in 1, the top dimensions being about 115 ft. by 95 ft., and the depth 11 ft. 6 in. The capacity of each cistern would be rather over 600,000 gallons or sufficient for a mean supply of 10 hours. The cisterns are built of 1 ft. 4 in. lime concrete, the exposed faces and bottom of each being cement-plastered. The cisterns are situated 3 miles from the reservoir, each cistern being connected with the 16 in. delivery main from the reservoir with a 16 in. inlet pipe which has its invert level at R.L. 94.50. Each inlet pipe has a 16 in. valve enclosed by a well of brickwork built in lime and cement-plastered. The water fills into

the well and then falls over a series of steps into the cistern. The outlet or delivery pipes from the cisterns are each 12 ins. diameter, and the invert of each pipe is at practically the same level as the bottom of the cistern, that is, at R.L. 90. Each cistern is provided with a 3 in. scour pipe placed on a slightly lower level than the delivery pipe. The 12 in. valve connecting the delivery pipe is enclosed by a valve chamber. There is a by-pass connecting the 16 in. main from the reservoir and the 12 in. delivery main, so that in case of accidents the water can be supplied direct from the reservoir without making use of the cisterns.

Shortly after one of the cisterns (No. 3) was brought into use it leaked very badly through the bottom and one of the sides on the slope of the hill, owing to water from springs having lodged behind the wall and floor of the cistern. The floor and side walls were broken up, and drains formed of loose rubble to take off the water. The new floor and side walls were built of 8 in. lime concrete and 4 in. cement concrete and have given no trouble.

Before concluding the section on service cisterns, it may be mentioned that there are no filters in connection with the scheme. It was intended to put down filters near the site of the service tanks, if found necessary after the first season's supply, but the necessity did not arise. The works were visited by the author during the flood season, and the water was quite clear. The probable reasons for the water not being muddy are that the surface formation of the catchment area is kept free from undergrowth, and that the dam affords shelter from the prevailing winds to the water in the reservoir, so that very little wave action is produced.

DISTRIBUTION SYSTEM.

The delivery main is calculated from the formula—

$$d = \frac{1}{3} \sqrt[5]{\frac{G^2 \times L}{H}}, \text{ where } L = \text{length of main in yards} = 5,000.$$

G = discharge in gallons per minute = 1,000, and H = available head in feet = 20, therefore diameter of main in inches

$$= d = \frac{1}{3} \sqrt[5]{\frac{1,000^2 \times 5,000}{20}} = 15.9 \text{ or } 16.$$

The delivery main is 3 miles long and connects the reservoir with the service cisterns, whence the water is distributed to the various parts of the town. The sizes and lengths of all pipes with the positions of standposts, hydrants, scour valves, air valves, and sluice valves are shown in Fig. 5. All mains and sub-mains up to 3 in. diameter and over are of cast iron, turned and bored, with spigot and socket ends. All distribution pipes below 3 in. in diameter are of galvanised wrought iron with screwed joints. The distribution of the population is shown in numbered blocks

(census wards), and from this distribution by blocks the diameters of the pipes required in each case have been calculated. The delivery main is 16 in. in diameter, and the service mains from 12 in. to 3 in. in diameter, the number of standposts being 115. The number of standposts with fire hydrants and plugs is 46.

All mains and sub-mains (cast iron) are coated inside and out with Dr. Angus Smith's composition. All mains are laid at least 3 ft. below ground, which is the minimum depth allowed on account of the probable influence of variation of temperature. For the same reason the galvanised wrought iron pipes are laid 18 in. below the ground. The service mains have been so arranged that there are very few dead ends. The requirements are based on a daily supply of 24 hours for the delivery main, 12 hours for the service main, and 8 hours for the distribution pipes. As the head of water does not exceed 300 ft. and the bore of the pipes is in every case less than 20 in., the thickness of the pipes is not governed by the stress due to hydrostatic pressure, but to the risk of breakage in handling. The least thicknesses recommended in "Notes on Indents for Pipes and other Stores for Waterworks" (issued by the India Office) are given in the table below, and the pipes used for the Moulmein Waterworks comply with these requirements.

TABLE OF THICKNESSES OF PIPES.

Bore of pipes in inches ..	Up to 4	4½ to 6	6½ to 8	8½ to 9	9½ to 12	13 to 15	16 to 18	19 to 20
Thickness in inches ..	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{7}{8}$

There is not much information at hand with regard to the distribution, but the following notes may be useful :—

The general levels of some of the roads through which the pipes run are as given below :—

General level of upper main road, 25 to 66.

General level of lower main road, 20 to 30.

General level of Strand Road, 24 (Great Trigonometrical Survey Mark on plinth of telegraph office, Strand 25·62.)

General level of Salween Park, 55.

General level of roads in Mutpun, 20.

General level of roads in Daingwunkwin, 18.

General level of roads in Cantonments, 35 to 68.

The standpipes and standposts referred to in the paper and shown on the plans are supplied with draw-off taps from which the inhabitants of the town draw water. There are no house

connections, but it is intended to have these later on for the European houses, and the better class of Burmans.

Water Rates.—The water rates fixed are $5\frac{1}{2}\%$ on the rental values of the houses.

Loans.—The following amounts were borrowed to construct the Waterworks :—

Public Loan Rs. 936,000 = £62,400, at 5% for 30 years.

Government Loan Rs. 106,000 = £7,067 at 4% for 20 years.

The author is unable to give the details of the sinking fund worked to liquidate the above sums with the accrued interests on them as he has not the full figures by him.

ABSTRACT OF COST.

	RUPEES.	£
Schedule No. 1.—Dam	376,240	= 25,083
Schedule No. 2.—Outlet Sluice	40,377	= 2,692
Schedule No. 3.—Escape Weir	25,407	= 1,694
Schedule No. 4.—Service Cisterns	54,794	= 3,653
Schedule No. 5.—Mains and Distribution	410,089	= 27,339
Miscellaneous.—Hydrants, Standposts, etc.	117,828	= 7,855
Total ..	1,024,735	= £68,316

To this must be added a further sum of Rs. 6,100—or £406—for repairs to No. 3 cistern, thus making a total expenditure of £68,722. The Municipality expects to incur a further small expenditure for fencing in the catchment area, and for a light communication bridge between the dam and outlet sluice wall.

Maintenance.—The budget allotment for the cost of working set apart by the Municipality for the year 1907 was Rs. 10,466 = £700 nearly, as it was found from actual working that the yearly expenditure would probably amount to that sum. This includes the salaries of the staff, as well as ordinary maintenance, but only about 50% of the Engineer's pay, or about £250, is charged to the Waterworks, the remainder of his pay being charged to other works connected with the Municipality.

CONCLUSION.

The works were executed by the Public Works Department, Burma, Mr. F. C. Lowis of that Department being the Resident Engineer under the general orders of Mr. G. T. Oliver, A.M.Inst.C.E., now Superintending Engineer, the then Executive Engineer of the Moulmein Division. Messrs. Burn & Co., Ltd., were the contractors. The pipes and fittings were supplied through the India Office. On completion of the works, which took practically two years, they were handed over to the Municipality.

DISCUSSION.

The **President** said he was sure the meeting would agree with him that a hearty vote of thanks was due to the author for his paper. The question of waterworks, and especially of waterworks abroad, was always of interest to engineers, but there were one or two points in the paper to which he should like to refer. The author had given some very elaborate formulæ for calculating the flow off catchment areas, but he should have liked the author to state results of actual observations and gaugings, as he considered that these results were far more important than results obtained merely from formulæ. The author also remarked that he was unable to obtain information as to the geological structure of the catchment area. This information he considered was most important to the scheme and should have been obtained.

The author had referred to a supply of 24 gallons per head per day for a population of 60,000 people. From his (the President's) experience of waterworks abroad, 24 gallons per head was certainly not sufficient when they were dealing with places where there was the liability of a large amount of waste. The very least that ought to be allowed was in his opinion 30 gallons a head. The author also mentioned that the full quantity that would be consumed during wet and dry seasons would be 209 million gallons and 317 million gallons respectively. He did not quite follow how the author obtained these amounts, because on the preceding page it was stated that the average periods of wet and dry seasons as deduced from the original statistics were 145 days and 220 days respectively. Perhaps the author could explain this.

In connection with headworks he did not see any reference made to trial holes with regard to the puddle dam, but probably the trial holes were made.

On page 85, it was stated "Service cisterns or tanks are used in order to utilise the full 24 hours' discharge through the delivery main and to store a day's supply in the town as a reserve." He considered that for a supply of this character three days' storage should be allowed for, and the storage of one day's supply was inadequate.

The formula which the author gave for the distribution system was, he thought, an old one. His (the President's) experience of these formulæ was that the more modern ones should be used whenever possible.

Referring to the distribution system the author said, "The standpipes and standposts . . . are supplied with draw-off taps from which the inhabitants of the town draw water." He (the President) was afraid that by entirely adopting this method there would be a large amount of waste. The author also said, "There are no house connections, but it is intended to have these later on for the European houses and the better class of Burmans. The water rates fixed are $5\frac{1}{2}$ per cent. on the rental

value of the houses." If the houses were going to pay at the rate of $5\frac{1}{2}$ per cent., he could not understand why there should be only standpipes. It surely would have been better to have had meters attached to the better class houses, and standpipes for the poorer population. He might mention that he was associated at present, with a scheme abroad for 40,000 inhabitants, 4,000 of the houses being supplied by meter. The water was sold to the poorer classes from standpipes, and charged at the rate of 2 reis per gallon. A rei being about 0.105d. It was anticipated that by this sale a return of £4,000 a year would be realised. The houses were charged at the rate of 6d. per 220 gallons.

The vote of thanks was carried unanimously.

Mr. J. F. Reade, in opening the discussion, said that he should like to express his appreciation of the quality of the papers which had been presented recently to the Society. They had struck him as being short, compact, and comprehensive, so that the members could easily get a grasp of the subject and enter into the discussion in a practical manner. Incidentally, of course, he had to congratulate the author of the present paper on the quality of his production, and also on the desirable position which he held with regard to the paper. The author had recorded what he had seen or had been told. But he could not be held responsible for the facts underlying the statements which the paper contained. Consequently criticisms of the paper would fall off the author "like water from a duck's back."

The paper described a rather usual type of waterworks. It was true that they were situated in a tropical country, and that, therefore, certain allowances must be made for differences, especially in the way of data forming the basis for the calculations. Those calculations appeared to follow the methods in vogue for similar undertakings in temperate latitudes, such as this country. He had his doubts as to the propriety of adopting the same methods of calculation for all climates and for all conditions. Certainly in this case the result seemed to justify the calculations, which appeared to be on the safe side. They must not expect too much in a new country in a more or less unknown part of the world. They could not expect that detailed study of the catchment area which might reasonably be expected in more civilised places. But the calculations could not be confirmed or otherwise, until such detailed study regarding the catchment had been made.

He was very much interested in the study of catchment areas. The study presented a great deal of difficulty, and there was not enough done with regard to it. It was curious to see how catchment areas varied in their results, even when situated in the same range of hills. In one case, for instance, the water became harder by 2 degrees at certain times, the cause for which was very difficult to assign.

Of course in the study of catchment areas the quantity and quality of the water was the essential point upon which everything centred. But there were many influences which governed and affected those particular points, and those influences ought to be studied with extreme care. The study involved, of course, an extensive knowledge of the natural sciences, such as meteorology, geology, botany, zoology, and many other 'ologies ; and engineers could scarcely be expected to undertake the work in its entirety. But, on the other hand, he did not see who else was to do it. Certainly the town clerk or the rate collector could not be expected to take the matter up.

The paper mentioned a point which was unusual in waterworks of this particular type, and that was the absence of filter beds. The author gave analyses of the water, but these analyses did not enable one to judge of what might be requisite in the way of purification in order to render the water perfectly safe for domestic use. So far as the analyses went, it could be inferred from the amount of chlorine in the water that there was a certain amount of security against the presence of sewage or excrementitious matter. And the author stated that such was the case. But, on the other hand, they had free ammonia and albuminoid ammonia in quantities which, to his mind, suggested something on the border line of a condition in which filtration would be a necessity. He should think, considering the state of affairs in a tropical country, that the water would be naturally teeming with animal and vegetable life. And this, taken in conjunction with the system of service tanks (which he supposed were open tanks), would lead him to think that filtration was decidedly required.

He wondered whether the question of the sterilisation of this water supply had been considered. This was one of the cases in which it might properly be considered. He did not intend to advocate sterilisation as ordinarily necessary, nor even advisable, but in certain cases it was a very good and reliable stand-by. In such cases, for instance, as an epidemic, such as occurred at Lincoln some time ago, in which case it was necessary to sterilise the water in order to guarantee the safety of the population from the epidemic. He should like to hear the opinions of other members with regard to sterilisation. The case against it seemed to be somewhat as follows. It deprived the water of all microbic life and brought the water into a bacteriologically pure condition. But it must be remembered that the water was not deprived of its power to sustain microbic life. Let it be granted that the water as delivered at the taps could not give rise to zymotic disease, but water before use had to come into contact with jugs, glass and other vessels, which vessels were seldom clean in a bacteriological sense. Microbes multiplied with great rapidity, and there might thus be introduced into the sterile water (which

retained its nutritive power) a far more virulent germ than the original microbic inhabitants of the water, the vast majority of which were known to be absolutely harmless.

He wondered why the author had inflicted on the meeting so many different units. For instance, in the analyses to which he had just referred, quantities were given in "grains per gallon," and, immediately after, in "parts per million." Later on there occurred the units "cubic feet" and "gallons." These differences might, of course, be an oversight on the part of the author, but he thought that the figures should have been reduced to one unit. They could as engineers think either in cubic feet or gallons, but to have to go from cubic feet to gallons and *vice versa* became a little tiresome.

There was one serious point which he must not forget to mention. The author said, "It would seem that the puddle trench had not been carried deep enough, as was evidenced from the number of leaks at various places, the total leakage being 3 cubic feet a second." Three cubic feet a second was sufficient to supply a population of about 69,000 people at the rate of 24 or 25 gallons a head a day. That is to say, more water was being wasted by leakage through the dam than was supplied to the town of Moulmein. That was a very serious state of affairs, and he regarded it as one of the most serious things which an engineer could encounter. In a puddle dam the nightmare of an engineer was this matter of leakage, and there was nothing which experience or foresight could in any way suggest to prevent the possibility of leakage occurring which ought to be omitted. An engineer was not only justified,—it was his duty to take such precautions as would avoid the least chance of the smallest leakage at any future time. He was afraid that in this instance something had been left to chance and hazard or something left undone, and the water, as usual, had found it out.

Mr. Percy Griffith said that he would take up the point last referred to by Mr. Reade, namely, the question of leakage, before he spoke of other points. That was really the most important point of the whole paper, and he was wondering whether the author would be able to interrupt him at once by saying that there had been a misprint in that part of the paper which referred to it. He had worked out the figures and found the case to be worse than had been suggested by the last speaker. 3 cubic feet a second made, according to his calculation, 1,620,000 gallons in a day of 24 hours. The works described in the paper were calculated to supply 1,440,000 gallons a day; so they had the very unusual case of works in which the amount of leakage was greater than the amount which they were calculated to supply. That fact would appear to reflect rather seriously upon the engineers who carried out the scheme, but there might be some explanation of it.

The scheme generally did not appear to him to present any characteristics special to a tropical climate, unless it was, perhaps, some greater allowance for the overflow, which of course was an important matter in a tropical climate with heavy maximum rainfall. As the last speaker had said, the author, not being personally responsible for the works, would not mind what criticism was made on the works, but he (the speaker) would rather have assailed the engineer who was responsible. However, this did not detract from the general interest of the paper. It was useful to engineers in England to get examples of works carried out in a foreign land, and especially in the colonies, and also especially when the works had been carried out by Public Works Department engineers. They formed a distinct branch of the profession. Moreover, an engineer who practised abroad had to have a very complete knowledge of many subjects, whereas engineers in this country were ordinarily confined to one branch of the profession, and did not need such extensive knowledge as their brethren abroad. For that reason English engineers ought to criticise works carried out by engineers abroad rather more sympathetically than they otherwise would, especially having regard to the peculiar difficulties which invariably met them in the carrying out of works. The works described in the paper were interesting, although they did not suggest any very wonderful or novel practice, being a good example of small works carried out under conditions which of course were very different from those which prevailed in this country.

The schemes which the author quoted as having been considered before the works were actually carried out did not reflect much credit on their authors, and personally he should have been inclined to omit the names of the engineers in referring to them. The collection of rain water from the roofs was hardly worth serious consideration. The second scheme would have involved pumping the water twice, at a very considerable annual cost. The third scheme was practically the one adopted. The fourth scheme, that of taking water from a river at low tide only, hardly seemed to compare with the scheme that was carried out, and did not deserve any very serious consideration.

The analysis of the water was obviously taken before the scheme was carried out, and no results are available as to the analysis of the water from the reservoir. It was known that in a tropical climate the greatest difficulty lay in the development of vegetable growth. In this case there might have been no organic pollution, but the risk of vegetable growth in the form of algæ seemed to be very great, and the difficulty might be a very serious one. While of course no one would suggest that algæ pure and simple would cause disease, they were often a vehicle for disease, if disease was obtainable from another source, and, at all events, they were a disadvantage. In any case

they usually caused discoloration and an unpleasant smell, and also gave rise to a very objectionable deposit in the pipes. The analysis of the water from the reservoirs, therefore, would have been of very great interest.

He should like to interject the remark that in his opinion the question of bacteriological and other analysis had been in many cases carried to an absurd extreme, and the results had not been of much advantage to anybody. In fact, in many cases enormous cost had been incurred for the purpose of meeting imaginary difficulties. He thought that analysts had worried water engineers a little bit more than was necessary in the elaborate precautions which they required engineers to take against conditions which had sometimes proved not to be harmful at all.

The sterilisation of the water at Lincoln was interesting to him, because he saw the process in operation soon after the epidemic, when the difficulties were very serious as affecting the Corporation, and although no doubt a perfectly satisfactory result was obtained he should not be prepared to connect the fact that the water supply was satisfactory with the process of sterilisation adopted. He thought that the sterilisation of the water was carried out rather to allay public anxiety than to produce any very serious effect upon the water itself. The result having been satisfactory, there was no harm in the fact being made known. At any rate, the sterilisation of water was, as the last speaker said, a very doubtful method of procedure. It was now well known that they might introduce into a room a little sterilised water and by the time that it had reached the end of the room it would on analysis be found to be full of microbes absorbed from the atmosphere during that very short period. That being so, the sterilisation of water at the source of supply would be perfectly useless as regarded the permanent elimination of harmful bacteria.

Another question was that of calculating the available supply of any watershed. The text books, like the paper, supplied a formula, and he was always amused when engineers tried to trap nature in a formula. He had always found that nature escaped from any such trap. In fact, the more rigid the formula, the more exceptions were there to the calculated results and the more unreliable were the calculations. The only test upon which the water engineer could rely was the gauging of the stream. There were of course difficulties in gauging mountain streams, but they were not insuperable, and the results of even twelve months' gauging would be more reliable than calculations based upon records of rainfall, percolation, and evaporation.

Speaking generally, as regarded the works as a whole, the leakage in the dam, unfortunately disposed of the congratulation.

which one would have otherwise given to the engineer on the success of the undertaking. The conditions were, however, very favourable, and if the bottom of the trench had been hard clay throughout, without a weak spot, one could not have asked for anything more simple and satisfactory, and no doubt the low cost of the works was accounted for by that.

The absence of filters was, of course, another most remarkable feature in the works. The author would perhaps deal with the point that had been raised as regarded vegetable matter in the water and discoloration. He had himself referred to mud or turbidity, but he (Mr. Griffith) did not consider that the removal of undergrowth from the catchment areas and the sheltering of the reservoir from the wind to prevent waves was sufficient to explain the absence of turbidity, and the author had made no reference whatever to vegetable growth in the form of algæ.

With regard to the remarks of the author on the thickness of the pipes, he (Mr. Griffith) did not know how many gentlemen in that room had come across a case where the hydrostatic pressures were the most important consideration in the thickness of the pipes. He should be very sorry to rely upon such a calculation. He thought that, for the most part, the result would be an extremely thin pipe. For practical use they adopted a rule which might be a little less scientific, but which was a great deal more reliable.

On the question of cost, the paper gave a figure of £68,000 for a works supplying a population of 60,000 people, or a little more than £1 a head. That figure was explained by three facts. One was the favourable conditions under which the dam was constructed. Another was that no filtration was provided. And the third was that it was a stand-pipe supply, and not a house supply. In regard to the latter question he would ask whether the consumers were willing to pay $5\frac{1}{2}$ per cent on their rental for having to fetch the water from the streets. Of course that depended upon the valuation of their houses, because that might be so low that it would involve a very small sum. In any event one would look forward to the time when the European houses, at any rate, would have the water laid on into the houses.

Mr. Henry C. Adams said that the author was to be congratulated on having given the Society the result of his observations on works in progress. The example might very well be followed, because there were many works which had not been definitely described in the technical papers or in the transactions of societies and as to which it would be extremely interesting to have information.

The paper stated, "the whole inner slope of the reservoir was

pitched with rubble stone, 1ft. deep, to protect the surface against the action of waves." The height of the dam at the deepest point was 68ft. There would be no wave action at anything approaching 68ft. deep. The paper might in some part give the minimum depth of water, that is the depth to which the water was drawn off, and surely, if the paving was extended to 20ft. below such low-water level, that would be quite sufficient to protect the slope from wave action.

He had been very much interested in hearing that portion of the paper where the service reservoir proved to be leaky. In order to stop the leak they adopted the very drastic course of breaking the walls up, putting in rubble drains, and then constructing the walls again. Of course, those walls were sloping 1 to 1, and possibly that was the only course that could be adopted, but he remembered trying to stop some small leaks in a service reservoir with a vertical concrete wall 24 inches thick. They spent an immense amount of time on the inside of the reservoir, and could not make any headway at all against the leakage, and eventually they excavated against the whole outside, rendered it and filled in the trench with puddle. It was a very long and expensive job to stop the leak, but it was completed satisfactorily.

The mains of the Moulmein waterworks, as they were told in the paper, were laid three feet below the ground to avoid the variations of temperature due to excessive heat. He did not know whether the author had any figures of experiments as to the actual depth to which heat penetrated. In this country there were available results showing the depth to which cold would penetrate. But if a depth of 3 feet was used for the mains, surely the service pipes might also have been laid at the same depth. He did not know how it followed that the service pipes should be laid at a depth of only 18 inches for the same reason that the mains were laid 3 feet deep.

Mr. C. T. Walrond said that he should like to know when the leakage amounted to the 3 cubic feet a second. Was it immediately after the works were constructed or had it been so for many years past, and also had the leakage shown any signs of increasing. Another question he should like to ask was with regard to the mains. They were turned and bored and had spigot and socket ends. He wondered whether any tests of soundness had been made, and whether it became necessary to caulk the spigot and socket end, or whether the engineers trusted entirely to the turning and boring; and also whether, the climate being a hot one, any difficulty had been experienced in keeping the mains tight during construction. In the part of the world where the works were situated, there had been difficulty with

regard to compressed air mains owing to the great variations in temperature, and even in this country he had found some little difficulty in hot summer weather in connection with air mains, before they had been covered in. The depth of the 3-inch main seemed to be rather shallow especially having regard to the greater depth of the larger pipes.

Mr. E. H. G. Brewster called attention to the necessity of being careful and observant when taking a sample of water for analysis. It fell to his lot many years ago to take such a sample from a well, when he discovered that the bore hole had been used as a water closet. This fact he would not have found out had he not been careful in making his observations of the surroundings.

Three reasons had been given by Mr. Percy Griffith for the cheapness of the work. There was a fourth reason, which was, that the land was given by the Government to the Municipality.

With regard to the draw-off cocks used in this scheme, he wished to ask the author whether those cocks were of the ordinary screw-down type, or of the waste-preventing type, the use of either of which would make some difference in the amount of water consumed.

A statement had been made with regard to the low amount of supply provided, viz.—24 gallons per head of the population. As the rainfall in the district was enormous, namely, 185 inches per annum as against 25 to 26 inches for London, and as it all came down in 145 days, it was probable that there was not very much water required during the wet period; this fact would account for the, at first sight, small amount of water provided per individual.

The President had told them of a scheme in which the water cost 6d. per cubic metre; that would work out at 27d. per thousand gallons. A doubt had been expressed during the discussion as to this being a paying scheme, but he (the speaker) thought that there was ample room left for a profit, for 1,000 gallons of water could be pumped in London at a cost of 4d., and the legal maximum charge of one of the old London companies for water supplied in large quantities was only 9d. per 1,000 gallons.

Mr. P. G. Scott communicated the following reply:—

As he was not directly responsible for the works, he was not in a position to answer all the points raised in the discussion, and it would not be just to the engineers responsible if he were merely to conjecture on those points, but as he had taken the responsibility of describing the works, he would reply to as many

questions as possible. He might say what Mr. Percy Griffith had said—he rather wished that the engineers who were responsible for the works were present to reply to the discussion.

As regards the leakage referred to by several speakers, he thought it almost certain that there was a mistake relating to that matter, and it would have been better if he had not bound himself to definite figures in that particular case, though he got them from official records. The quantity of leakage, however, was greater than usual, and the author drew attention to that fact in order to gain knowledge from some of the members present as to the effect certain depths of water had on certain soils. In the case of the Moulmein Reservoir trial holes were made, but they were probably made in the dry season, and very likely the soil was not as retentive as it appeared. The head of water was therefore too great, and it percolated through the soil and below the puddle wall, thus finding its way out again.

As regards the remarks made by the President, Mr. J. F. Reade, and Mr. Griffith, he agreed with what they said regarding formulæ for calculating the flow off catchment areas, and he thought the best way was to gauge the streams supplying the reservoir during a long period when possible, because there were several factors which had to be considered with regard to catchment areas, the flow off which depended not only on the rainfall but also on the configuration of the ground, the manner in which it was wooded, the evaporation, and the geological formation (which he thought was the most important of all). It was not, however, always possible to gauge streams for long periods, as when a water supply scheme was proposed, it had to be carried out almost immediately, and an engineer had to depend on rainfall statistics. In the author's opinion if the streams feeding the reservoir were gauged for a period of, say, 12 months (as was possible in most cases), and compared with the rainfall for that period, and observation made for evaporation, the quantity of water absorbed and spent in the sustenance of plant life could be ascertained for all practical purposes, and the percentage of water available with regard to the rainfall for the period under observation would be known. By applying this percentage to the driest year and to the average rainfall for a long series of years (assuming such rainfall statistics exist) an engineer would at once know the quantity of water he had to deal with for calculating the storage capacity of his reservoir.

With regard to the President's remark that he did not follow the statements that 209 million gallons and 317 million gallons would be consumed during the wet and dry seasons respectively, the author would state that his figures were quite correct, as a consumption of 24 gallons per head per day for a population of

60,000 people for 145 days (wet season) would give a total consumption of 209 million gallons, and similarly the total consumption for 220 days (dry season) would be 317 million gallons. The President and Mr. Percy Griffith had stated that $5\frac{1}{2}$ per cent. on the rental values of the houses was very high, but that was not the case with regard to the Moulmein Waterworks, as the rental values of the houses in Burma were very low, and the consumers were quite willing to pay the amount stated.

Replying to Mr. J. F. Reade, the cisterns referred to are open. As regards epidemics, there were a number of cases of cholera annually before the waterworks were constructed, but since the waterworks were constructed there was not a single case within the author's knowledge.

As regards the low cost of the work referred to by Mr. Griffith and Mr. Brewster, two other factors should also be considered, and those were cheap labour and careful supervision by the officers of the Public Works Department.

In reply to Mr. C. T. Walrond, the author would state that the leakage noted in the paper was observed practically immediately after the completion of the works, and in his (the author's) opinion the leakage was likely to lessen considerably, as the dam was carefully built and the leakage, though great, could not possibly have been as great as that stated. As regards the joints of the pipes, the author would state that, in a similar waterworks (though a smaller one) constructed by him, every tenth pipe was leaded, but in the case of the Moulmein Waterworks the following extract from Mr. Foy's specification will dispose of the point raised:—
 "All pipes to be turned and bored so that joints will fit tight and not require leading, but packed with hemp dipped in red lead solution: an occasional lead joint to be introduced to allow for the elongation and contraction caused by changes of temperature."

In reply to Mr. Brewster, the draw-off taps were of the waste-preventing type and not of the ordinary screw-down type.

In conclusion, the author would state that though in other engineering works British engineers in the Colonies or in foreign countries are second to none, and that some of their works are of even greater magnitude than those in Europe and have to be constructed under far more difficult conditions, both as regards the resources of the country and the labour available, yet he must admit that as regards waterworks and sewage disposal schemes engineers abroad are not quite up-to-date, and have a good deal to learn from English engineers, but the tendency is for improvement and the author trusts it will not be long before such schemes will be quite up to the standard of those in Europe. He is of

opinion that the Moulmein Municipality is to be congratulated on having had constructed for them so excellent and cheap a Waterworks by the Public Works Department. He (the author) was present at the meeting not only to read his paper, but to learn from the experience of others what was being done, and what should be done, and what avoided, in the preparation of a water supply scheme. He was not disappointed in that respect, and was obliged to all those gentlemen who took part in the discussion.

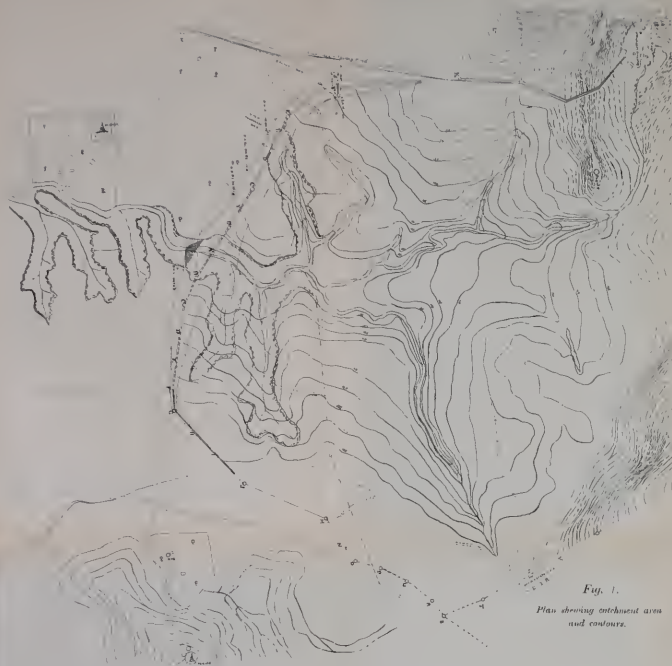


Fig. 1.
Plan showing outflow area
and contours.

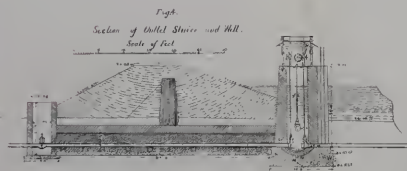


Fig. 4.
Section of Outlet Works and Mill.
Scale of feet.

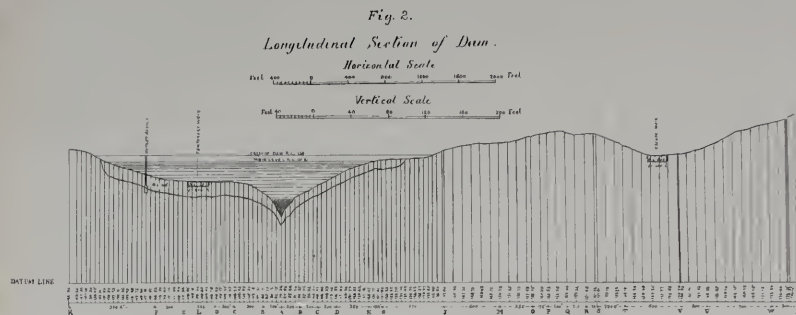


Fig. 2.
Longitudinal Section of Dam.

Horizontal Scale

Vertical Scale

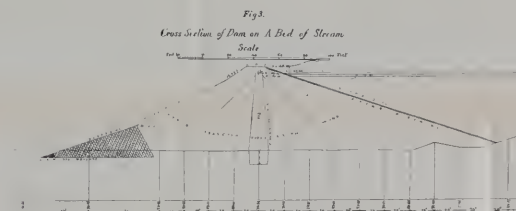


Fig. 3.
Cross Section of Dam on A Bed of Stream.
Scale



Fig. 5.

Plan showing Standpipe Hydraulics etc.
Scale

May 2nd, 1910.

F. G. BLOYD, VICE-PRESIDENT, IN THE CHAIR.

UP-TO-DATE ROADS.

By R. O. WYNNE-ROBERTS, M.INST.C.E.

OWING to the great increase of traffic on the roads, it is necessary to alter the methods of construction and maintenance, so that they may be better able to withstand the attrition and concussive action of self-propelled vehicles. Much has been written on this subject by different persons, dealing with it from various standpoints, and although two or more papers have been read on roads and questions appertaining thereto before the Society of Engineers during the last few years, the author, believing that there is still ample scope for further study, does not think an apology necessary in directing attention to the matter of "Up-to-date Roads."

The following notes have reference only to macadamised roads, and as it is essential that each class of highway should be dealt with in a particular manner, according to its character, its purpose and the traffic, it therefore follows that a classification of roads is necessary before any standard of construction or maintenance can be evolved.

CLASSIFICATION.

At the present time the classification of roads is somewhat anomalous and ambiguous. There are main, subsidised, urban and rural roads without any defined national or provincial limitations having been established. Each county authority has adopted its own classification, apparently without regard to that authorized in the adjoining counties. Some main roads, for instance, rightly constitute the principal arteries between different parts of the country, whilst others are quite unimportant local roads.

For the purpose of this paper the author proposes to divide the highways into four classes :—

- (1) National Roads.
- (2) County Roads.
- (3) Urban Roads.
- (4) Rural Roads.

(1) National roads would comprise those which carry through-traffic from one part of the country to another, traversing two or more counties, such as the Bath Road, Great North Road, etc. These roads, as the name implies, would be maintained either under the direct control of a State department, or by subsidies from the

State exchequer to the County Council, who would themselves undertake the work. Where such roads pass through towns with a larger population than say 20,000, the urban district council would undertake the work of maintenance under the supervision of the State or County Council.

(2) County roads would comprise those highways which serve mainly as the principal connections between towns and villages in a county, but do not carry much through-traffic as in the case of the National roads. These roads would be maintained out of the county rate, and therefore would be under the direct control of the County Council.

(3) Urban roads would be those situated within the area of Urban districts having a population of 20,000 and over. When they constitute a connecting link between the adjoining county or national roads, they would be subsidised by the County Council or the State, subject to these authorities being satisfied as to the quality of the work.

(4) Rural roads would be those which do not come into the foregoing categories, but, should the traffic exceed some defined standard, part of the cost of maintenance would be borne by the County Council, provided the work performed was satisfactory.

No doubt the above classification will not be ideal or complete—indeed, it is probably impossible to formulate a scheme for this purpose which would not create some minor anomalies, but in view of the rapidly growing necessity for a more equitable distribution of the financial burden of constructing and maintaining roads, some form of classification must ultimately be adopted, before a fair allocation of the annual expenditure can be made.

The author considers that the question of traffic should be fully considered when the matter of classification is investigated.

WIDTH.

A large number of the highways are narrow, tortuous, and steep, and were not constructed to carry the present-day traffic; much has been, and will be done to improve these conditions. The principal question to-day is, not the construction of new roads, excepting in the case of new connections between important towns, but the improvement of existing ones. Roads which would be classed as "National" should have a width of 40 feet on the carriageway, and at least one footway say 6 feet wide. In view of the increased traffic as the centres of population are approached, the width of carriageway should be enlarged to 50 feet or 60 feet, with a footway on each side. "County" roads should be 30 feet wide, increasing to 40 feet near the towns, with one 5-foot pathway. "Urban" roads should conform with the highways they connect, and "Rural" roads should have a carriageway of 15 feet to 20 feet wide with one 4-foot path.

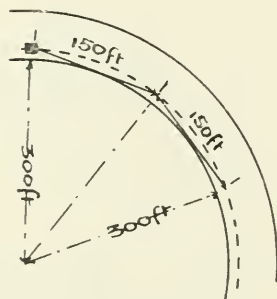
GRADIENTS.

It is desirable that gradients should be as small as possible, both on account of the cost of upkeep of the road surface, and of the expenditure of energy required to surmount them. The advent of the motor-car has introduced additional disintegrating forces on road surfaces, especially on hilly roads. It is a question whether the annual cost of maintaining diversions or loop roads to avoid some steep gradients would not effect a tangible economy.

Five per cent. grades would probably constitute a reasonable maximum ; on "National" roads even this should be exceptional. The tractive effort required to overcome the resistance on gradients has an important bearing on the wear and tear of highways. The energy required to draw a load up a gradient of 1 in 20 in dry weather on creosoted wood block pavements is more than twice that necessary on grades of 1 in 100, and according to the experiments made by Parnell, Gayfflier and others, and recently by Mr. R. J. Thomas, M.Inst.C.E.,* this ratio is more or less correct for macadamised roads.

CURVES.

The question of the safety of motorists and other road-users is necessarily an urgent one, and under the present conditions the rounding-off of sharp elbows and the straightening of tortuous highways is of more or less pressing importance, according to the density of the traffic. A number of accidents have occurred at sharp corners, which are not always observable until they are reached, when travelling at moderate speed. On "National" and "County" roads, where high-speed traffic will be predominant, the curves should be such that the drivers can see ahead for a sufficient distance to enable them to stop the vehicle, and thus to avoid accidents. Motor cars, when driven at a moderate speed, can be pulled up in about 10 yards, but to avoid unnecessary risks the driver should have a clear vision ahead of say about 150 feet. When there are high embankments, trees, buildings, etc., on the roadside, blocking the vision, and the motor car is driven on the inner side of the curve, it will be seen that the radius required will be about 300 feet (Fig. 1).



CAMBER.

FIG. 1.

The camber necessary to permit of the surfaces being efficiently drained, without causing the sides to be too steep for comfortable

* "Road Maintenance and Administration," April 6th, 1903.

travelling, depends on the materials used, the longitudinal gradients, etc. Soft, absorbent macadam requires a higher crown and steeper sides than hard, impervious metal, but the more camber that is given to a road the greater is the tendency for the traffic to keep to the centre. This necessarily causes the central portion of the road to be subjected to greater wear and tear, and when repairs are made this part is liable to be raised still higher. Many highways have excessive cambers, and need modifying so that the whole carriageway should bear a proportion of the traffic. The camber for durable detritus-bound macadam surface of level longitudinal sections should be about 4 per cent. of the half width of carriageway, but when the road is tarred or covered with tar macadam the camber can be reduced to 3, $2\frac{1}{2}$, or even 2 per cent. Then for a 40-foot carriageway, a water-bound macadam road, the crown would be $\frac{40 \times 4}{2 \times 100} = 0.8$ feet or 9.6in. ; tar macadam road $\frac{40 \times 3}{2 \times 100} = 0.6$ ft. or 7.2in., or $\frac{40 \times 2.5}{2 \times 100} = 0.5$ ft. or 6in. respectively.

When the road "hangs," that is when the channels are not on the same level, the above rule will apply, but the position and height of the crown will be altered.

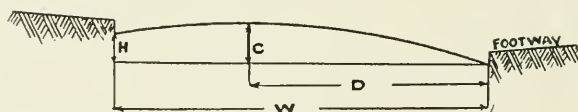


FIG. 2.

Let D = Distance from crown to lower channel in feet.

W = Width of carriageway in feet.

C = Height of crown in feet above lower channel.

H = Hang of road in feet.

P = Percentage of camber expressed as 0.02, 0.03, etc.

$$D = \frac{P \times W^2}{2 \times P \times W - H} \quad C = P \times D.$$

EXAMPLE 1.—30ft. road hangs 0.5ft. ; camber 3 per cent.

$$D = \frac{0.03 \times 30^2}{2 \times 0.03 \times 30 - 0.5} = \frac{27}{1.30} = 20.8\text{ft.}$$

$$C = 20.8 \times 0.03 = 0.624\text{ft.}$$

EXAMPLE 2.—24ft. carriageway hangs 0.75ft. ; camber = 4 per cent.

$$D = \frac{0.04 \times 24^2}{2 \times 0.04 \times 24 - 0.75} = \frac{23.04}{1.17} = 19.7\text{ft.}$$

$$C = 19.7 \times 0.04 = 0.788\text{ft.}$$

The position and height of the crown having been fixed, the contour of the road can be made to conform with a curvature on the lines shewn in Fig 3.

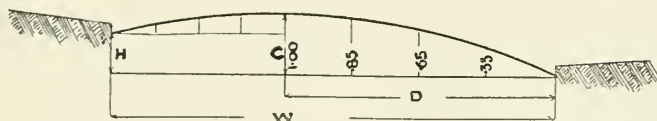


FIG. 3.

The distance between the crown and the channel is divided into four equal parts. Taking the elevation of the crown as unity, the above constants can be used to ascertain the other heights. Thus in the first example $D = 20.8$, each division on the lower side will be 5.2ft. wide, $C = 0.624\text{ft.}$, the other points will be 0.53, 0.405 and 0.22 respectively. The upper side of the road will be $30 - 20.8 = 9.2\text{ft.}$ wide, the divisions will each be 2.3ft. wide and the height of crown $0.624 - 0.5 = 0.124\text{ft.}$, above the higher channel, other heights will be 0.105, 0.081, and 0.0435. In practice such small divisions will doubtless be discarded, and a gentle curve connecting the crown to the upper channel will be substituted. The above constants can of course be applied to lay out the contour of roads having channels on same level.

The foregoing rules must be modified when the longitudinal gradients of the road exceed, say, 1 in 200.

SUBSOIL.

The important bearing which the subsoil has in relation to the efficiency and economy of road maintenance is one which is recognised by all road engineers. Many scores of miles of our roads are constructed on wet, clayey, loamy or marshy subsoil, and under the action of the traffic and climatic conditions considerable trouble is experienced by roadmen in maintaining a satisfactory surface.

DRAINAGE.

The only permanent remedy for the above defects is efficient drainage. The subsoil water should be intercepted by means of trenches partially filled in with loose stones, and afterwards covered in. Agricultural drain pipes laid in these trenches permit a more expeditious discharge of the water, and the additional cost is small. The position of these trenches depends on the local conditions, such as the natural configuration of the adjoining land, the nature of the subsoil, etc.

FOUNDATIONS.

A large proportion of the highways were built up by simply laying an accumulated thickness of macadam on the ordinary subsoil, which, as already stated, is often wet and clayey. Under the pressure applied by heavy loads hauled over these roads, macadam is pressed into the subsoil, causing the mud to exude to the surface and in dry weather to be ground into dust. Roads of this character sufficed under the ordinary traffic which prevailed previous to the advent of self-propelled vehicles, but these vehicles have exposed the weak spots throughout the country, rendering it necessary to adopt adequate measures of reconstruction and maintenance.

The functions of road foundations are :—

1. To carry loads without subsiding.
2. To distribute the pressure imposed on the surface.
3. To support the surface material.
4. To prevent the subsoil from exuding upwards.
5. To maintain a dry road surface.

Although it is not possible to state definitely in what manner the pressure imposed by a loaded wheel on an even road surface is transmitted to the subsoil, it is reasonable to postulate that the lines of pressure diverge downwards at an angle varying from 30 to 50 degrees to the vertical, according to the solidity and quality of the road fabric, in which case the stress-lines assume the form of a truncated pyramid. If the road surface is uneven or loose stones lie about, the lines of pressure become more concentrated, when the wheel passes over such excrescences.

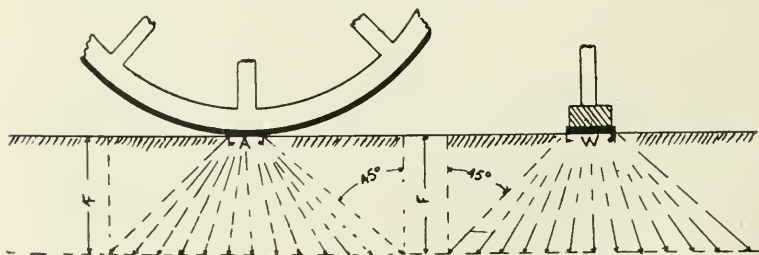


FIG. 4.

Let P = Distributed pressure on subsoil per sq. inch.
 A = Length of arc of wheel in contact with hard road surface in inches.
 W = Width of tire in inches.
 L = Load carried by the wheel.
 F = Depth of foundation and macadam in inches.
 C = Area of contact surface.
 then $C = A \times W$.

The area of the base of the pyramid, according to Fig. 4, will be

$$(2 F + A) \times (2 F + W) = B.$$

and the distributed pressure on the subsoil will be—

$$P = \frac{L}{(2 F + A) \times (2 F + W)} = \frac{L}{B}$$

Let it be assumed that the load is 10 cwt. per inch width of tire, the tire is 3in. wide, the arc contact is 3in., and the total thickness of the road fabric is 12in.

$$P = \frac{L}{B} = \frac{10 \times 3}{(2 \times 12 + 3) \times (2 \times 12 + 3)} = \frac{30}{27 \times 27} = \frac{30}{729} = 0.041 \text{ cwt. per sq. in.}$$

As very many roads have no foundation, but consist of an accumulated thickness of macadam varying say from 4in. upwards, the effect of the above load on the subsoil is intensified. Take a road having a thickness of say 6in.

$$P = \frac{L}{B} = \frac{10 \times 3}{(2 \times 6 + 3) \times (2 \times 6 + 3)} = \frac{30}{15 \times 15} = 0.133 \text{ cwt. per sq. in.}$$

In this instance the distributed pressure on the subsoil owing to the absence of suitable foundations is therefore increased over threefold. It is evident that, under present-day traffic, such roads are liable to be seriously damaged by internal disintegration.

The author does not contend that the foregoing theories or calculations are accurate, but submits that they offer a tangible reason why the cost of maintenance has increased so much by the introduction of heavily loaded mechanically-driven vehicles. The destructive effect of heavy high-speed traffic is greatly aggravated by unevenness of road surface.

Much can be added to these observations on the influence of excessive camber, tractive effort and other points, but enough has been stated to shew that substantial foundations capable of resisting the deformation of the road surface, the disintegration of the entire fabric, and the permanent disturbance of the subsoil, are necessary and conduces to ultimate economy.

The depth of foundation depends on the sustaining powers of the subsoil, the method of construction, and the intensity of pressure imposed by wheeled traffic on the road surface; it will, however, range between 6in. and 12in. in thickness.

MACADAM.

The question of employing macadam which will sustain the traffic without crushing and disintegrating is of paramount importance. Although laboratory tests have been made with reference to attrition, absorption, strength, etc., the results of which are doubtless useful to indicate the characteristics of different stones, they do not afford road engineers the information

which is of much value in actual practice. More useful and reliable data would be obtained by conducting careful census of traffic on different roads, observing the wearing qualities of macadam from various sources, and afterwards correlating the same with the laboratory tests according to some defined standard. Some engineers have taken considerable interest in this subject, and have from personal experience amassed much information which would be of great value to others engaged on road works.

The method of applying macadam has an influence on the efficiency and economy of maintenance ; when recoating a road, the old surface should be made as loose as possible ; this, however, is not always done, and the rolling of macadam on a hard road tends to crush the stone, rendering it less durable and less satisfactory. The grouting of interstices with liquid detritus is gradually becoming obsolete, especially on the principal highways, various bituminous and other materials being now largely used instead.

BINDERS.

There are many bituminous compounds on the market for the purpose of binding together the road-metal, and thus largely reducing the inter-attrition caused by traffic on macadam. The author does not propose to deal with the different commercial binders individually, but as they consist mainly of coal tar either with or without other ingredients, it will suffice if this commodity alone is dealt with in this paper.

Coal tar is one of the most complex mixtures which chemists have had to investigate, and although it has been under examination for upwards of 50 years, new discoveries are continually being made. From the road engineer's point of view, however, this liquid has probably been sufficiently investigated to indicate under what conditions it is best suited for road works. As by far the largest quantity of tar used on roads is obtained directly or indirectly from different gasworks, it is necessary to point out that as the coals, methods of carbonisation, and other important factors differ, so does the quality of the tar vary. Even when the same coal is consumed it is remarkable how the variation in the quantity of coal charged into each retort, different temperatures, etc., will produce tar of a different character. It is therefore of the utmost importance that road engineers should understand how this product is manufactured before they can apply the same with any reasonable assurance of success.

The following diagram will suffice to illustrate the various apparatus installed at a gasworks. Fig. 5 (see next page). The temperature of the furnace A and flues is usually from 2,000 deg. to 2,300 deg. Fahr. The retort B is a long fire-clay tube, round, oval or $\ominus$ shape in cross section, and is connected by means of an ascension pipe to the hydraulic main C, in which there is water and tar to seal the outlet of the above pipe. Coal is

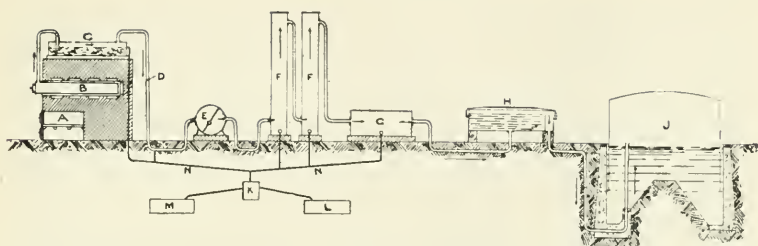


FIG. 5.

DIAGRAM OF APPARATUS INSTALLED AT GASWORKS.

charged into the retort, which is afterwards hermetically closed by a lid. The gases and vapours pass up the ascension pipe through the water seal into the upper part of the hydraulic main. Here the heavier hydrocarbons, etc., are condensed and extracted. The gas then travels through the condensing main D, which, as its name implies, causes a further quantity of tar and ammoniacal liquid to condense, and is then drawn through the exhauster E, forced through the condensers F and the washer and scrubber G, where the last particles of tar and water are extracted. After passing through the purifiers H the gas is discharged into the gasholder J where it is stored ready for consumption.

The tar and ammoniacal liquor are collected from the various apparatus as shewn in the diagram and drained by pipes N to the separator K, where, by virtue of the difference in specific gravity, the tar subsides to the bottom and is conveyed to the tar-well L, and the ammoniacal liquor drained to its tank M.

The foregoing is a succinct description of the process of gas manufacture and the production of the by-product tar. There are a large number of coking ovens in operation where the by-product tar is recovered, and the rapidly increased number of such coking ovens erected in this country will result in the production of a large quantity of tar. Although there are many points of interest to road engineers in this connection, the author must confine his observations to gasworks tar.

As the temperature of the furnaces and flues is not maintained at the same pyrometric level at all gasworks, the tar must differ. The high heats maintained at the larger gasworks under certain conditions produce tars of great density, whilst at country gasworks, as the temperature is somewhat lower, this product is less viscous.

The practice which was almost universal until recently, of partially filling the retorts with coal, is now changing into fuller charges, and this has a great influence on the composition of the tar. Furthermore, vertical, "slopers" and chamber retorts are

being extensively adopted at the larger gasworks, with the result that the molecular arrangements of the constituents of the tar are altered. In fact, there is every prospect that the tar produced at most of the larger gasworks will soon be altered in composition, by increasing the charges of coal, and by installing other forms of retorts.

Thick crude tar is not a positive proof of its quality as a binder, for on the one hand it is more retentive of moisture, and on the other it has in all probability a high percentage of free carbon, neither of which are beneficial to the binding properties of the tar.

The separation of the water from tar is not an easy matter. Some of the tars produced in the Metropolis, for instance, are sponge-like in their retentive powers. The question of effective dehydration is an important one to road engineers, because water acts as a deterrent against the efficient adhesion of the tar to macadam, since there is a greater affinity between stone and water than between stone and tar.

It is often found when boiling crude tar in ordinary kettles that it is liable to boil over and ignite; as this is almost entirely due to the presence of water, it is important that moisture should be eliminated as far as possible. At some gasworks the tar is heated by steam coils, which reduces its viscosity and causes the water to rise more quickly to the surface to be drained away.

All tars should be heated before being applied on the roads. Care must be taken, however, not to raise the temperature of crude tar above 150 deg. Fahr., or it will be liable to froth over. If the above temperature is maintained for about two hours most of the moisture will be driven off.

As free carbon has no binding value, and is liable to be converted into black dust or mud, it follows that tars containing the smallest percentage of free carbon are best for road work. The selection of tar can only be made by separating the products from different points, that condensed in the hydraulic main being usually the most heavily charged with free carbon. At present the tars from all parts are drained to one point, and consequently selection is impossible; this, however, will doubtless be changed as road engineers become more acquainted with the virtues and defects of this product.

Tar also contains a considerable quantity of light oil and naphtha, which act like diluents, and unless they are extracted they volatilise on the road surface, leaving a skin which is not as durable as it might otherwise be. If it happens to rain immediately after the road surface is tarred, the oils are apt to emulsify and be washed into the gutters, and ultimately into the water courses. Boiling tar in ordinary cauldrons will not drive out the light oil, etc., as it is not possible to raise the temperature sufficiently high without causing it to overflow. These con-

stituents can be extracted only by distillation, and this means the provision of suitable stills, etc.

Distillation of tar, is comparatively a simple process. The author, nearly 25 years ago, erected a 3-ton plant which has been worked by ordinary workmen without any serious mishap. The plant necessary to distill say 2 or 3 tons consists of a wrought iron still, condenser and a cast-iron tank. If the still is a permanent fixture, it is usually a vertical cylinder with a convex bottom, and a domed top, built in brickwork, or it can be erected like a vertical boiler lagged with non-conducting material so as to reduce the radiation of heat.

The condenser consists of a tank containing a wrought or cast iron worm placed in water, the object of which is to condense the vapour passing out of the still.

The still is usually filled two-thirds full with tar, and is at first gently heated. Care must be taken in firing, until the temperature in the still reaches about 224 deg. Fahr. as the tar is apt to prime over and cause inconvenience. After this the temperature is considerably increased. The first distillate coming over is naphtha and water, then light oil, each of which should be stored in separate casks. When the specific gravity of the distillate is equal to that of water, namely 1.00, the distillation for refined tar is completed, and when cooled down the tar is drained into the tank for storage and use. In some cases the distillation is carried on until the carbolic oil, creosote, naphthalene, and anthracene have been extracted, leaving pitch as a residue in the still. When distilled tar is required, a sufficient quantity of carbolic or creosote oil is returned into the still to make the consistency of the pitch conform with a defined standard.

The author has, in the foregoing observations, only cursorily explained the process of distillation, as a more detailed description would suffice for a separate paper.

Owing to the variability of the quality of crude tar, its use, without prolonged boiling, cannot be recommended, and even then it is not equal in durability and uniformity of results to that obtained by the use of refined or distilled tars. Proprietary tars consist mainly of refined or distilled tars with the addition of other ingredients.

Inasmuch as refined or distilled tar is not obtainable at most gasworks, there is good reason for road engineers to erect either stationary or portable distilling plants, the cost of which will necessarily vary according to their capacities. As the use of tar on roads is of recent development, the number of distilling apparatus installed by local authorities is at present limited, but, with more intimate knowledge, gained by experience, engineers will be able to stipulate the more essential requirements as to the quality of tar. The adoption of such distilling plants will doubtless become more general in the immediate future.

It is possible to design a portable distilling apparatus, which can be operated by an intelligent workman, on any convenient point on the roadside, to produce refined or distilled tar of an uniform quality to conform with any workable standard or specification. Such an apparatus would be useful, as effective boiling could be carried on with economy and the minimum of risk, and the tar would be ready for use in the manufacture of tar macadam, tar-sand grout, tar-chip grout, or for tarring road surfaces. The author has designed such a plant.

Testing of tar.—The most satisfactory methods of testing tar must necessarily be those employed by analytical chemists in their well equipped laboratories, together with more or less prolonged observations of the effects of climate and traffic. The more essential tests as to the quality of tar are :—

1. Specific gravity.
2. Viscosity.
3. Percentage of free carbon.
4. Adhesion.
5. Percentage of moisture.
6. Loss by evaporation.
7. Loss by fractional distillation.
8. Percentage of fixed carbon.

The usual tests are too elaborate and tedious for use by road engineers. There are, however, some simple ones which can be employed by them to obtain sufficiently reliable working comparisons, and these are applicable for the first five of the above list.

The simple tests only will be referred to in this paper.

Specific Gravity can be ascertained by means of a Twaddell hydrometer (Fig. 6) which for convenience should have the degrees and specific gravity figures clearly marked. This instrument when immersed in the tar sinks to a depth according to the density of the liquid. Refined tar should have a density of about 50 deg. Tw. or 1·250 specific gravity. To convert Twaddell degrees into specific gravity; let Tw. be the number of degrees Twaddell, then specific gravity = $\text{Tw.} \times 0\cdot005 + 1$. For example 50 deg. Tw. = $50 \times 0\cdot005 + 1 = 1\cdot250$ specific gravity.

Viscosity.—The hydrometer can be used to ascertain the viscosity of tar. This instrument should be first immersed as far as 50 Tw., or 1·250 sp. gr., and taken out to drain for two or three minutes. Then with a seconds watch in view, the hydrometer should be allowed to sink into the tar, and the time it takes to

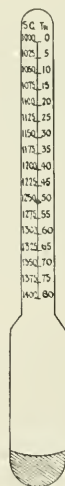


FIG. 6.
TWADDELL
HYDROMETER.

subside to the above-mentioned point noted. This should be done two or three times and mean results taken.

Free Carbon.—The same hydrometer can also be used to ascertain with approximate accuracy the percentage of free carbon contained in a tar. Mr. Warnes, an eminent authority on tar distillation in this country, has prepared a formula which is applicable for Midland and probably other tars.

For Twaddell degrees, free carbon = $0.8N - 10$.

N = number of degrees.

If specific gravity only is shewn on hydrometer, then

Sp. gr. - 1.000 $\times$ 160 - 10 = percentage of free carbon.

The percentage of free carbon in crude tar should not exceed 25.

Adhesion.—No instrument has yet been devised to ascertain satisfactorily the adhesive quality of tar compounds. Tests for ductility are easy and simple, but as the action of the traffic on macadam is that of impact, tending to separate the stones from each other, ductility does not constitute a factor of prime importance. It must, however, be regarded as of some value. The author is investigating the question of a satisfactory test for adhesion, and hopes shortly to bring out an instrument for ascertaining the comparative adhesive qualities of various tars.

Moisture.—There should not be any moisture in refined or distilled tar, but when crude tar is employed, a simple test for ascertaining if the moisture has been driven out by boiling is that suggested by Dr. Rideal, namely by placing a cold glass plate over the cauldron. If any steam is being evolved it will condense on the plate.

Application of Tar.—There are three methods in which tar is used on road works: (1) tarring the surface, (2) mixing with macadam, (3) grouting the macadam in situ. Each of these has its advocates.

Tarring.—To ensure good results, the road should be dry, not only on the surface but also for a depth of two or three inches. A dry, warm surface will facilitate the distribution and absorption of the tar. The road surface should be in good condition, even, and free from pot-holes. Newer surfaces are preferable to older ones, as the interstices are not so closely filled in. Dust and dirt should be thoroughly swept off the surface, and the joints between the macadam exposed. The tar should be heated to 150 deg. Fahr., and if crude, boiled for about two hours and applied hot. If grit, chippings or sand is used, it should be frugally spread, and the surplus removed as soon as possible. The tar should be allowed ample time to soak into the road surface before applying the sand, etc. It is, however, a debatable question whether any sanding should be done at all, excepting in the neighbourhood of houses, for this practice tends to retain the tar on the surface instead of allowing it to percolate into the joints.

Tarring by hand is under better control as to heating, distribution and percolation than machine spraying, because the area treated is smaller and more attention can be given to the work by the roadmen. This process is, however, a slow one, and as our climate is somewhat erratic, road engineers desire to avail themselves of short spells of dry weather in tarring as large an area as possible. The distribution of tar under pressure causes the liquid to be atomised, in which condition it must, in the author's opinion, be rapidly reduced in temperature, and thus render the tar more viscous than is desirable.

The advantages of tarring road surfaces are so manifest that they need not here be referred to. There are also certain disadvantages; the surfaces are liable to become slippery, and in autumn, greasy black mud is often produced. Furthermore when crude tar is used, as already explained, there is a danger of polluting the watercourses and streams.

The economy of tarring roads is generally an appreciable one, —less watering is required, the macadamised surface is more durable and the public experience greater comfort.

Tar Macadam.—There is a closer affinity between tar and limestone than between it and granite. Limestone appears to absorb the tar more readily and to adhere more firmly. Granite if dry and carefully mixed with tar will, however, make an excellent road material.

Refined, distilled or prepared tars only should be used for the purpose of tar macadam, and, after mixing, it is advisable to allow the same to mature for several days.

The quantity of tar required per cubic yard of macadam will vary, according to the texture and porosity of the stone used.

As slag is used in the manufacture of "tarmac," it might be inferred that owing to the inherent variability of its quality, due to the different proportions of materials used at ironworks, its durability as a road material would be inferior to natural stone. Doubtless this is the case, in some measure, yet, as a rule, its employment when mixed with tar gives satisfaction. The author has observed that even ordinary cinders mixed with well boiled crude tar will stand considerable traffic, but the blows caused by the unloading of carts on the pavement resulted in the formation of depressions; when this pavement was taken up, the material was found to be exceedingly tough and difficult to remove. The results of boiling cinders and stone in tar are remarkable, but space will not permit of dealing with this matter.

Grouting.—Refined, distilled or prepared tars mixed with hot dry sand form an excellent bituminous grouting. The City Engineer of Liverpool has used a similar grout with satisfactory results. In this case the labour of mixing macadam and tar is obviated. The dry macadam is rolled to an even surface, the grout is poured on the top, and worked into the interstices by

brooms and squeegees. The steam roller is run over the grouted macadam and the whole fabric consolidated, forming an impervious, durable and smooth roadway.

The subject of "Up-to-date Roads" is so extensive that it is impossible to deal with every phase in one paper. The author acknowledges there are many points of interest which might be referred to, but the more salient features have been dealt with.

DISCUSSION.

The **Chairman** said that before passing on to the discussion he was sure that those present would support him in conveying the best thanks of the Society to Mr. Wynne-Roberts for the paper he had read to them. The subject that he had dealt with was one that appealed with a considerable degree of insistence, not only to engineers and surveyors, as the persons responsible for the construction and maintenance of our highways, but also to the public at large, as the users of the roads.

Many points of practical interest were touched on in the paper, but, as the author acknowledged in the concluding paragraph, the subject was so extensive that it was not possible to deal with every phase of the question in a single paper, and many other points would, no doubt, be forthcoming in the discussion.

Briefly, he would sum up the subject under three heads: (1) Design, (2) Construction, and (3) Maintenance, and would suggest that, although at the outset these three heads might appear to be quite distinct from one another, and did, indeed, represent three separate operations that were frequently undertaken by three different branches of the profession, yet, he thought, all would agree that a perfectly satisfactory and efficient road was only obtained from a happy combination of those heads, based on the particular lines required for the locality and the user of the road.

He would now move that the best thanks of the Society be accorded to Mr. Wynne-Roberts for his paper.

The vote of thanks was carried by acclamation.

Mr. H. P. Maybury said that he wished to express his thanks personally to Mr. Wynne-Roberts for the very lucid way in which he had dealt with a complicated subject. He agreed that the principal points which the Chairman had mentioned were of great importance, but the most important was that of finance. All sorts and conditions of men told engineers how the roads ought to be dealt with, but they never told them where the money was to come from. During the afternoon he had been attending, as a visitor, a meeting of the Farmers' Club, and, singularly enough, the subject dealt with was up-to-date roads. At that meeting he heard a respected Member of Parliament say

that the Road Development Act which had just obtained the sanction of Parliament was absolutely of no use to the community. He thought that no gentleman who held such views ought to be a member of the House of Commons. He (Mr. Maybury) said unhesitatingly that the Road Development Act was one of the best measures which had been placed upon the Statute Book. It admitted for the first time of State aid in the construction and the improvement of roads. The discussion at the Farmers' Club was confined to the improvement and construction of new highways. If the Road Development Act would only help his county to the extent of the improvements which the county from time to time carried out, it could have assisted them in the financial year which had just passed to the extent of something like £16,000. Last year £13,000 was spent in tar-painting roads in the County of Kent—that is, in dust abatement—and £3,000 in incidental improvements, and the Act referred to enabled the Road Board to contribute towards dust abatement as it did towards improvements. His experience of road engineers was that they endeavoured to get value for money, but no engineer could make bricks without straw, nor carry out improvements or dust-abatement work without money.

The author had very nicely and very happily referred to the great improvements which had undoubtedly been made during the last few years in the maintenance of highways; but he had certainly not overstated the case. Great alterations had taken place in the traffic since 1903. Previously to that year no motor car could legally travel upon the roads of this country at a higher speed than twelve miles an hour. At the end of 1903 there were not, he supposed, more than 1,000 motor cars and motor vehicles on the roads, but at the end of last year there were 190,000 such vehicles. Increased traffic had thus been put upon the roads, but the funds which had been placed at the disposal of engineers were inadequate to meet the increased cost of maintenance. No apology was required for the improvements which had undoubtedly taken place in the condition of the roads of the United Kingdom, having regard to the increased amount of traffic which passed over them. The County Council of Berkshire had applied to the Local Government Board to sanction the expenditure of a sum of £60,000 in improving some 27 miles of main roads within that county. That had been referred to in some quarters as a most heroic measure and applauded as such; while Lord Montagu had said the other day, in *The Car*, that it was a course which other County Councils would do well to emulate; but he (Mr. Maybury) would deprecate anything of the kind in his own County of Kent; and he believed that most County Councils were public-spirited enough, and had a sufficiently high sense of the duty imposed upon them, to provide sufficient money year by year to keep their roads in order,

rather than pile up a debt to make amends for the lâches of the past. It was most unfair that a county which had allowed its roads to go down should be applauded now for doing something drastic in the endeavour to bring them up to the standard of some of the other counties.

He noticed the author's suggestion that it would not be an impolitic thing to have a tar-still upon the side of the highway. If Mr. Wynne-Roberts had lately had charge of highways and had used tar on the roads, he would know that the very sight of a tar-boiler to some people was almost like a red rag to a bull. In his (Mr. Maybury's) county and others the tar-boiler had resulted in numerous claims having been received. During last year he had had to defend an action for, as he was told, poisoning a cow, and the County Court Judge believed the statement, notwithstanding all that he (Mr. Maybury) could do to controvert it, while damages and costs were actually given against the County Council. He had also had a claim for damage to damson trees, and for damage to hops, and a thousand and one other things. He had no intention of following out Mr. Wynne-Roberts's suggestion, namely, to put a tar distillery alongside a county road, excellent though the idea might be.

There was no doubt that tar had a very beneficial effect upon the life of a macadam road. In these days of heavy motor traffic on the main trunk roads, it would be impossible to hold them together without tar treatment. As the author stated, the old system of binding with detritus and water would soon be a thing of the past. It was a primitive and makeshift process at the best. He did not think that tar painting was by any means the last word in the maintenance of highways, but certainly it went a long way to enable the roads to withstand the requirements of present-day traffic and to reduce the road bill. In his own county they had 750 miles of road, 303 miles of which were treated with tar last year, and he was glad to say that notwithstanding this additional work so far they had not got back to the expenditure which existed in 1902. In that year the main roads of the county of Kent cost £162 per mile. Last year they cost £137 per mile, including tar painting and improvements. The reduction of the cost was due to the fact that they now obtained granite and other materials upon very much more favourable terms than was the case in and prior to 1902; and therefore what they had "lost on the swings" they had "made up on the roundabouts."

His friend Mr. Butterfield and he had been making various experiments in the endeavour to get a proper and suitable bituminous binder which should, to some extent, supersede the use of tar and tar paint, and which would, at all events, have the effect of giving them a road with the elasticity that was required to withstand high-speed traffic.

He noticed that the author, in his formula, gave weight and thrust and angles, but he appeared to ignore altogether the question of speed. Speed and weight were synonymous. If a motor car, or a traction engine, or any other vehicle was travelling at only two miles an hour, obviously the strain upon the highway was nothing like so great as with the same vehicle going at a rate of, say, twenty miles an hour. The diagram seemed to regard the traffic simply as a rolling load.

The paper suggested that there should be a classification of roads, and that certain highways should be classed as national or state roads. There was a very great difference of opinion amongst road engineers as to the wisdom of such a policy. At the International Congress on Roads, held at Paris, the conclusion arrived at was that national roads would be a mistake. There was a national road system in France, and English people had always been told that the French road system was the one to be followed, and that it represented the perfection which ought to be aimed at. Mr. Thomas, the County Surveyor of Buckinghamshire, in reporting upon the Paris Congress to his Council, referred to national roads in these words: "Serious deterioration was perceptible in the uneven and worn sett paving, in the excessive cross section—usually nearer 1 in 15 on macadam roads than the French academic 1 in 50—in the stripped, worn-out, and wavy character of macadam surfaces, in the numerous extraordinarily deep holes left unattended to, in the deep grooves worn by motors at corners, and in the soft, dust-making quality of metalling used. As instances, the road from Paris to Versailles and from Paris to Melun, especially north of Bourgeon, was such as to compare unfavourably with any road within a similar distance of London."

Since the holding of the Congress and the inspection of those roads, English people had heard very little of state control. Public opinion brought to bear upon the officers who were responsible for the maintenance of roads was a great factor. Under state control everything would be organised from Whitehall. Every road engineer in every part of the country would have his instructions and would have to obey them to the letter, being responsible only to Whitehall. Then there would be what was spoken of as "uniformity." Uniformity was the wrong thing for engineers, and was another word for mediocrity. He would put it to the meeting with confidence that what was wanted was that one engineer should try to do better than his neighbour. Under such a system they would encourage individual initiative and individual ambition. If everything was directed from Whitehall, the engineer would probably get his instructions bound round with red tape, telling him to put, say, Rhenish basalt on a road at Dover at a cost of, say, 17s. 6d. a ton, whereas if he had to act on his own initiative, he could use an equally

good material costing, say, 8s. 6d. a ton. He would assert with great confidence that public and local influence brought to bear upon the matter was the surest road to efficiency and economy. Under state control, if the Government granted a certain sum of money for the roads, the engineer would have to spend it whether he wanted it or not. There must never be a balance. He understood that it was always better for the Government engineer to exceed his estimate than to be under it. Therefore he had a small disagreement with Mr. Wynne-Roberts in his suggestion that some roads should be put under national control. Give the present engineers money and give them public opinion forcing their hands towards the improvement of the roads, and it would be found that the county surveyors and the local engineers would be quite equal to their task.

Mr. Butterfield said that he had had some experience of the manufacture of tar and of prescribing tars of a suitable character for painting and treatment of roads. Coal tar was, he believed, an older product than coal gas. The properties of coal tar were described pretty fully in a pamphlet by the ninth Earl of Dundonald, which bore a date (1785) earlier than the time of the discovery of coal gas. At the date of that pamphlet it had not been proposed to use tar on roads. He was not sure that he agreed with Mr. Wynne-Roberts that it would be very helpful to the road engineer to understand how coal tar was manufactured. A little knowledge of that point might lead to dangerous errors.

He thought that a high specific gravity had very little bearing on the suitability of coal tar as a binder, and that it did not connote, as Mr. Wynne-Roberts implied, that the tar contained a certain proportion of free carbon or that it would have a certain viscosity. The properties of the tar were dependent almost entirely upon the temperature at which the coal had been carbonised. The character of the coal was of practically no account, provided that the temperature of the carbonisation exceeded a certain minimum. As to free carbon, it certainly had no binding value, and the suggested maximum of 25 per cent. for the quantity permissible in tar for road use was, he thought, too high. In specifications which he had drawn up he had generally put it at 16 per cent. He did not think that it was practicable for the average tar distiller to produce a satisfactory tar with a specific gravity of 1.25; 1.20 to 1.22 was practically the average density of refined or freed tar which was suitable for painting roads. For the manufacture of grouting materials they wanted a different tar altogether.

He had been struck, as Mr. Maybury had been, that the author dealt with loads on the roads as static or slowly rolling loads, and took no account of the speed of the rotation of the

wheels. As a matter of fact, the necessity for the tar treatment of the roads came in with the increased speed of the traffic. The wheel of a vehicle might be regarded as a grindstone, and the road as an article which was being ground. If this grindstone were revolved very rapidly it would wear away the road surface very quickly if the pressure or weight were considerable. If the surface of the road could be easily ground up and disintegrated, the wear and tear on the road would be very great. To prevent the wear and tear being very excessive the surface of the road had to be bound together with a highly viscous liquid or colloidal material which could not be easily torn apart and which would not be ground up, but would rather be pulled into strings when the effort was made to tear it apart. He conceived that that was somewhat the condition that they had to deal with when the rapidly rotating wheels of to-day were passed over the roads. That was the *raison d'être* of the application of tar to the surface of the roads. The tar was not easily pulled apart when once it was set, and, incidentally, it prevented lumps of road materials from being pulled apart, ground one upon another, and thus broken up, and preserved the whole of the road surface from disintegration.

With regard to many points referred to in the analysis of tar, the paper was necessarily very general, and there must be points of disagreement; but there was one point as to which he would warn engineers who made their own tests of tar. The author had not been sufficiently explicit with regard to the test for viscosity. The viscosity of a liquid such as tar was very largely a function of the temperature. It all depended upon the temperature at which they made the test. A tar which was highly viscous at 40 degrees Fahrenheit would be a relatively freely fluid tar at 70 deg. Fahrenheit. There was no reference in the description to the fact that temperature was an extremely important factor. Obviously a tar which was suitable for road use must be one which had a fairly uniform viscosity over a widish range of temperature.

He wished to add his thanks to those which had been expressed to the author. The paper covered a very wide range of points, and it was hardly possible or reasonable to discuss it in detail.

Mr. Reginald Brown said that Mr. Wynne-Roberts had no need to apologise for offering a paper on the subject of roads. All road engineers knew that there was plenty to be said about it and plenty of difference of opinion as well. The author was very brave to attempt to classify roads as he had classified them.

Like Mr. Maybury, he (the speaker) could not see why the state should want to enter into the business of road authorities at all. As Mr. Maybury had said, the local authorities or their engineers had plenty of knowledge of local requirements to

prompt them to put down sufficiently strong roads, and roads suitable for their districts, without any interference on the part of the State. Also, he did not quite see why County Councils should interfere with road authorities. Mr. Maybury spoke from a County Council point of view, and he was quite right in doing so, but if he had been the engineer to an Urban Council he would not have spoken in the same way. He agreed with the state contributing towards the cost of the main roads; and he also agreed with the County Council contributing to the local authority towards the cost of maintaining the roads through the district of such local authority, and in a far greater proportion than they did at present.

Mr. Wynne-Roberts was very moderate as to the width of highways throughout the country; but who was to bear the cost of widening the roads? If the cost fell on the local authorities it would mean a very heavy burden upon the local rates; and if it fell on the County Council it would bring a heavy burden upon the county rates.

He entirely disagreed with the views of Mr. Wynne-Roberts as to the question of pressure on the foundations of the roads. The question was often raised in the law courts. He did not agree that the pressure was distributed over the foundation in the way suggested in the paper. The pressure must be concentrated somewhat in the form of an inverted pyramid rather than in the form of a truncated pyramid; and, if the matter was examined carefully, it would be found that under the centre of the wheel there must be a bigger depression than on the outside of the wheel. Mr. Codrington, the then Inspector-General of Roads in Wales, gave, in a very admirable paper written some years ago, some very good results of tests that he had made with wheels on various surfaces. The diagrams of the tests showed clearly the effect of pressure upon foundations of certain materials. They proved that the pressure, instead of being spread over the area suggested by the author, was considerably increased towards the centre of the wheel. This was no doubt true, and it showed, partly, the reason why there was such a tremendous effect from motor cars and other heavy vehicles going over the surface of a road. He did not think that anyone who was at all connected with highways would accept the view that 18 cwt. per square foot was an excessive weight to put upon the foundation of a road. Mr. Roberts mentioned 0·133 cwt. to the square inch, which represented only 18 cwt. to the square foot. No one would agree that, with statical pressure only, 18 cwt. was too heavy for any roadway. They must take into account the question of the speed of the vehicle as it passed over the road, and also the fact that the pressure was not distributed in the way which Mr. Wynne-Roberts suggested, but was increased towards the centre and below the centre.

With regard to the question of tar binding, there were various qualities of tar, but he did not agree with the author that engineers should understand all about how to get certain qualities of tar. They should leave that matter to the people who made it their business to produce the tar. But, still, "a little knowledge" was not "dangerous," unless it was applied in a dangerous way. There was no doubt that the tendency of gas companies was to use a lot of water gas in the manufacture of ordinary town gas and also to enrich their gas, and hence there would be a lot of difference in the qualities of the tars they produced. As they increased the proportion of water gas or oil gas, so the differences in the quality of the tar would be increased. There was, no doubt, great difficulty in getting the water out of the tar, but by simple deposition a great percentage of the water could be removed. Oil-tar could be got with as low a specific gravity as 1.08, which was very slightly above ordinary water. He had used a tremendous lot of oil-tar during the last three years. In fact, he had been told that he (Mr. Brown) had gone mad about oil-tar. He had himself used oil-tar for the last three years on the surface of the roadways. The advantage of using oil-tar was that it contained a low percentage of pitch. They got about 25 per cent. in oil-tar of what was got in ordinary coal tar; that is to say, there was about 58 per cent. of pitch in ordinary coal tar and about 14 or 15 per cent. in oil-tar. The pitch in oil-tar was in such a liquid condition that it permeated the whole of the road surface in a cold state much more quickly than ordinary tar would do when heated. What they wanted was something that would penetrate into the whole of the surface of the road, and the thinner they could get the pitch and the more they could get it into the interstices of the material, the better would the road be bound together. He had found that oil-tar would penetrate into the roadway for at least 2in. Of course, everything was a question of £ s. d. (as Mr. Maybury had pointed out), and from this point of view local authorities were concerned principally for the ratepayers. If they took the ordinary coal-tar dressing (refined tar as it should be) at a penny a yard super, oil-tar could be done at less than one-fourth, or five dressings could be given for a penny. He took it that with oil-tar, if they gave the road five dressings, which very few roads indeed would require, they would get a road equally efficient with one dressing of ordinary coal tar. He could show many roads which had been bound for the last three years with oil-tar, and they only required one dressing per annum, at a cost of less than $\frac{1}{4}$ d. per square yard.

The author stated in his paper that tar should not be covered with chippings, and he gave the reason; but he (Mr. Brown) claimed that if they were to use a thinner material and a smaller amount of pitch in a more liquid state, they would not require to use sand or chippings on the surface at all. As a matter of fact,

with oil-tar they would not have to use a barrow of sand in ten miles, for within two or three hours the surface of the road would be fit to walk upon without the use of any such material. He remembered reading a short time ago a very interesting work written by his friend Mr. Walker Smith, the Borough Engineer of Edinburgh, on the question of tests for tar, and he gave in the paper the results of some experiments which he had tried on the subject. Instead of using a hydrometer to ascertain the viscosity, he took into consideration the question of temperature, and he took tar heated at various degrees of temperature and used small discs on the surface of the tar, noting the time that it took for the tar to cover the discs at varying degrees of temperature. That method in his (Mr. Brown's) opinion gave a very simple and accurate idea as to the viscosity of the tar which was being used. He also gauged the adhesion by a very simple instrument indeed. He attached cubes together, had a handle attached to the end one, and drew them apart; the power required to draw them apart being shown on a spring balance, which indicated the comparative adhesion.

As to the question of tarring by hand, there was no doubt that it was better than tarring by machinery, but in this country we had not got a climate, but only had samples of one, and engineers liked to get the roads done as quickly as possible. That was the reason that they had to make use of machinery; but with hand tarring they could get the liquid into the surface of the roadway better than they could by machine.

He had not tried the grouting which was described in the paper. From what he had heard he believed that, as used by Mr. Brodie at Liverpool, it was admirable, and he (Mr. Brown) intended to try the material on a road before long.

Many years ago he used slag macadam, and he believed that it was a very admirable material. The material is not a new one, but had been used for a considerable number of years, and roads done with such material were still in a very good state where there had not been very excessive traffic.

Mr. Maybury was very sanguine about the Road Development Act, but he (Mr. Brown) was not. Mr. Maybury thought that the Government would put their hands into their pockets and assist County Councils and local authorities to do certain work. He (Mr. Brown) did not think so, but he hoped this would be the case.

In referring to the question of national and County Council roads, Mr. Maybury declaimed against the control of roads by the state. He said that there would be uniformity in the construction of the roads, and he deprecated that very much. The claim of the majority of the County Councils was that, if the roads were under the control of the County Council, there would be uniformity. He (Mr. Brown) did not think that at all. He

quite agreed with Mr. Maybury in the view that each district should try to do better than its neighbour. That was the only way in which they would be able to get at the truth of the matter of proper road construction. Of course, the only way was to construct the roads properly from the very beginning. But to do so would cost too much money nowadays. The districts could not stand it.

English engineers could carry out roads quite as well as French engineers, and as well as they could be carried out in France, but they must have the money. English engineers could not learn anything from France with regard to road engineering. English engineers were, however, run down by Englishmen, and people said to them, "Go to Germany; go to France; see how they do this, that, and the other." But he thought that if English people would look at home and support English engineers, and put their hands a little more deeply into their pockets instead of grumbling, English engineers would do their duty and would give them roads which were fit for any traffic likely to come upon them.

Mr. Percy G. Scott wrote that he had read Mr. Wynne-Roberts's paper with great interest, as he had had to deal with the design, construction, and maintenance of various classes of roads in India, both in the plains and the hills, and, in his opinion, the paper would be useful to engineers in the Colonies and India as well as in England; but its value would have been enhanced if the author had dealt a little more fully with such important points as drainage, gradients, and the method of laying and spreading the macadam.

The results of observations on the wear and tear of roads, taking into account the class, amount, and speed of traffic, the materials used, and the depth of foundations and surface layer, would be useful to all road engineers, and he hoped that those who had made such observations would give them to the Society. Laboratory experiments did not afford sufficient data, and, as the author rightly pointed out, observations made on the road itself, where natural influences play such an important part, should be correlated with laboratory experiments.

The author did not state the size of the macadam used. In India it was the practice to use stones that would pass in every direction through rings 2in. and 1½in. in diameter, the bigger stones being used for the under layer and the smaller for the upper layer, the consolidated macadam being 9in. thick and the camber of the road 1 in 24.

The material used for the macadam and its suitability to the various kinds of traffic were of the utmost importance. When visiting certain parts of the Peak District (Derbyshire) about eleven years ago, he had noticed that the surfaces of most of the roads in that district were always covered with a thick layer of

dust or mud, due, no doubt, to the very rapid wearing away of the limestone macadam ; from which it appeared that limestone macadam was only suitable for light traffic. Of course the material used should be that which would prove to be the cheapest in the long run, taking into consideration all factors, such as cost of construction and maintenance and the nature of the traffic.

Information as to the weight of steam rollers used, and the speed at which they should generally travel in order to give the best results, would also have been of much value.

As regards the classification of roads, he might remark that in India the roads are constructed and maintained from Provincial, District, and Local Funds. The Provincial roads are under the control of the engineers of the Buildings and Roads Branch of the Public Works Department, and the District and Local Fund roads are looked after by District and Local Fund overseers or supervisors. The latter class of men are under the orders of the Deputy Commissioner of the District, who, of course, is not an engineer, but who occasionally gets advice from the nearest Public Works Engineer. Owing to the meagre knowledge of the overseers and supervisors the roads are seldom in good condition, and it would lead to a better state of affairs if a qualified District Engineer were appointed, under the orders of the Commissioner of a division, to look after all the roads and other District Fund work in that division ; the division being parcelled out into Sub-Divisions (irrespective of the Districts under the charge of the Deputy Commissioner, and according to the number and importance of the roads and other works), each in charge of an Assistant Engineer, who should be responsible to his own District Engineer. The latter in case of doubt in professional matters would get the advice of the Chief Engineer of the Public Works Department.

As regards the use of tar, he had noticed in the "Daily Mail," of May 3rd, 1910, a letter from Mr. R. B. Marston, Editor of the "Fishing Gazette," complaining of trout and other fish being poisoned owing to "the modern system of road-tarring." No doubt something could be done to remedy this.

REPLY.

Mr. Wynne-Roberts, in reply to the discussion, said that he was very gratified with the reception which his paper had had. He quite expected criticism. Some of the items in the paper did not exactly represent his views, but, to induce discussion, he had expressed them in a controversial manner, otherwise there would possibly have been nothing but "Amen" from most of the members because he had said something with which they agreed.

With regard to the formula for viscosity, he at once recognised that there was an omission of something which he had

intended to put in. When the proof came into his hands other things had distracted his attention, and he forgot to insert the information. Viscosity certainly could not be ascertained with anything like reliability unless they adopted some standard of temperature or range of temperature, as Mr. Butterfield had explained. With regard to the formula about the pressure on the foundation, that was given to show the relative and not the actual pressure. He had distinctly stated that he did not claim that the theory put forward in the paper or the calculations were accurate. They were sufficient to show that the pressure on the subsoil intensified with the reduction of thickness of the road. If they had a roadway 12in. thick and the pressure was distributed, heavy loads drawn over it would have a certain effect on the subsoil, but the pressure would be much more aggravated when they had a thinner road surface. He would like to impress upon members that a very long length of the highways in this country had no greater thickness than from 4in. to 6in. Therefore, they would see that when even static loads were applied there was a disintegrating influence on the fabric, and when the rolling impact of wheels was also considered, they could quite understand that the vibratory action of wheels passing over roads which were weak under ordinary conditions would then be in a very much worse condition. He agreed with what all the speakers had said to the effect that the speed must be taken into consideration; for the purpose of the paper, he had, however, dealt with static loads only.

No doubt the introduction of a portable tar distillery on roads was not quite the ideal thing, but his object in advocating such plant was to facilitate the work. Many authorities in the country had no tar distillery works within an economical distance, and consequently they were thrown upon the use of crude tar. That was clearly shown by the experience of various surveyors. It was to meet this condition that he suggested a portable tar distillery. There were plenty of points on a roadway where it could be put without creating very serious inconvenience to the public.

Great stress had been laid by Mr. Maybury on his (the author's) advocacy of national roads, but he thought that Mr. Maybury would agree that the classification at the present time was not a satisfactory one. One County Council may have practically the whole of its roads or the greater portion of them as main roads, and another county, not quite so generously disposed, may not have anything like the same proportionate length of main roads within its borders, so that the conditions were quite different. In one county, highways which were wholly unimportant may still be main roads, but in the next county, important arteries are not made main roads, so that there was a real necessity for the question of classification of roads to be

inquired into. He did not see how they could differentiate between the maintenance and improvement of various roads unless they first classified them. It was more or less hopeless to deal with them as they were classified at present. He made the reservation in his paper that it was not necessary that the roads should be maintained directly by the state. He had clearly said that that duty could be delegated to the County Councils. Therefore Mr. Maybury and he were of the same opinion, it was only a question of the *modus operandi*.

There were several very interesting points raised by Mr. Maybury, but he did not need to traverse through them all.

With regard to the introduction of motor cars, the point which he had to bring forward in the paper was that the change in the conditions which had taken place within the last ten years had been so great that it introduced new difficulties and problems to be grappled with by road engineers, put new burdens on the authorities, and brought new ideas to the travelling public, and that therefore something must be done to meet them. Methods of construction and maintenance must be changed, and that was actually taking place throughout every county, and rightly so. Mr. Maybury had taken as prominent a part in that direction as any county surveyor in England, and had done his share of road improvement.

It had been mentioned by Mr. Butterfield that the specific gravity did not connote the presence of free carbon. That might be correct. Mr. Butterfield had better opportunities of judging of that than he (the author) had ; yet, from the information which he had received from eminent chemists and tar distillers, he believed that they all agreed that specific gravity in some measure did connote the presence of free carbon. For instance, Mr. Warnes, of Birmingham, the chemist to Hardman's tar distillery works, had laid it down that specific gravity did connote the presence of free carbon. He thought that Mr. Butterfield would agree with him. Mr. Warnes had produced the formula given in the paper which gave the percentage of free carbon in tars. He should be very glad to know where he was wrong. Mr. Butterfield was, no doubt, a recognised authority on tar from the chemist's point of view, and they therefore had two doctors disagreeing ; road engineers were consequently at a loss to know who was right. Perhaps both were right from different points of view.

Mr. Butterfield, interposing, said that when tar was obtained within a limited area where gas works were using the same description of coal and the same methods of carbonisation, the specific gravity of the tar probably did indicate roughly the proportion of free carbon ; but, taking it over a wide area, with gas works, scattered all over the country, using different descriptions

of coal and different heats, they could not say that the specific gravity of the tar had any definite relation to the proportion of free carbon in it. He thought that that accounted for the difference. Probably the statement had been made with reference to a tar gathered over a limited area.

The **Author**, continuing, said that he was extremely obliged for the explanation, but he would like to point out that the information which had been given to him pointed to the fact that the formula given in the paper was more or less accurate for all tars except metropolitan tars. Mr. Butterfield's explanation may no doubt be correct, but it did not correspond with the analyses supplied by Mr. Warnes, on which the author had acted. Mr. Butterfield stipulated that the free carbon should be limited to 16 per cent. That at once eliminated all metropolitan tars, which, if he (the author) was correct, as a rule contained a much larger percentage than 16. He thought that they would find on analysis that free carbon contained in the various tars of the country exceeded 16 per cent. Probably 25 per cent. was rather high, but he had mentioned that figure to ascertain what were the opinions of members with regard to it. American chemists limit free carbon to 20 per cent. He thought that, according to analyses, Mr. Butterfield's limit meant that tars from many gas works could not be used, or at any rate they had to be differentiated or selected from certain points.

A specific gravity of 1.25 might be a little too high; but still some tars which were used at the present time had that density. Possibly a slight modification to 1.22 might be better.

With reference to the action of the wheels on the road, to which Mr. Butterfield had referred, he liked his explanation and his simile comparing the wheel to the grinder and the road to the article being ground. He thought that it was an excellent example of what took place on the road surface. With regard to the use of the bitumen that was available in this country, they had various compounds of tar and so on, which acted as excellent binders between stone and stone. Another action which took place on the road surface, and which he endeavoured to explain in the paper, was the impact action of the wheels tending to the separation of the stones. The tar binders resisted this tendency, and it was the adhesive quality of the binder that he desired to measure or value.

Reference had been made by Mr. Brown to the tests made by Mr. Walker Smith by means of a screw and a spring balance, as used for testing cement, but in his (the author's) opinion that was not a proper test for adhesion. It was really a test for ductility, because when two stones bedded in bitumen were gradually drawn apart, the bituminous material was drawn out in a number of threads. That was not the test which he liked to see applied,

nor was it the test which American engineers or chemists were seeking. They were seeking a test where the action of the wheel tending to separate the stones by a blow, and not by gradual tension, could be repeated in a laboratory and the force measured. Mr. Walker Smith's test might be useful for ascertaining the ductile value of tars, etc., as he (the author) had stated in his paper; but, admirable though it might be, it did not give the information which he required.

With regard to viscosity and the discs that Mr. Brown mentioned, it was a question of which to use. That must be settled by experience and practice. But the one suggested in the paper as the tar-tester—the hydrometer—seemed to be the simplest. There was not the necessity of buying a multiplicity of instruments, because one hydrometer would do three tests. He did not claim that it would give the accurate information which would be got in laboratories; but for working tests which would enable intelligent foremen like those employed on the roads to know that they were using tar of a certain quality, the hydrometer tests would give sufficient indications as to its quality.

He thanked the meeting heartily for the manner in which they had received his paper.

VISIT TO THE WORKS OF CASSELL & CO, LTD.

The first vacation visit of this Session took place on Thursday, May 19th, 1910, when, by the courtesy of Mr. James Walter Smith, Chief Editor, a party of members of the Society and their friends visited the printing works of Messrs. Cassell and Company, Ltd., La Belle Sauvage, Ludgate Hill, E.C.

The originator of the business was John Cassell, who, about 1843, having an idea that there was a great demand in the field of literature for cheap publications, established himself as a printer and publisher, doing the whole work single-handed. Shortly afterwards he issued "The Standard of Freedom," a weekly newspaper, at the then popular price of 4½d., and later he founded "Cassell's Popular Educator," which was issued originally to bring education into the homes of the people, and still retains its popularity.

The works, which give employment to about 1,000 persons, cover an area of nearly two acres, and consist of six floors. Five of the floors are built in the form of galleries, surrounding a well, over which is the glass roof giving light to all the floors,

and especially to the ground floor, where all the heavy printing machinery is placed. On the sixth or top floor is situated the composing room and the electrotyping department ; on the fifth floor are the stereo foundry, press room, colour room and store rooms ; on the fourth floor the lithographing department, magazine room, plate room, news stereo foundry, and offices of the art department ; on the third floor the editorial offices and the electro sales department ; on the second floor the warehouse ; and on the ground floor the machine room and paper store.

On the level of La Belle Sauvage Yard are the publishing and advertising departments. Immediately above the publishing office is the counting-house on the first floor, stock department on the second floor, and the binding department on the third and fourth floors ; whilst opposite, on the other side of the yard, are the offices of the general press, production and publicity departments, and the editorial offices of several publications.

The composing department is very up-to-date, containing as it does a large battery of Linotype and Monotype composing machines, and a perusal of the magazines published by this house is evidence of the skill and workmanship employed in this department.

The stereotyping and electrotyping departments are well fitted to cope with the tremendous amount of work which a business like that of Cassell and Company requires done at short notice.

In the machine department the machinery is all of the latest type both in flat-bed and rotary, and on one floor alone there are as many as forty machines printing the various publications of the house.

In the bindery may also be seen some of the latest appliances invented to cope with the vast amount of work which flows into this department from the machine room, and comprises folding, gathering, wrapping, stitching, glueing and cutting machines.

VISIT TO THE L.C.C. TRAMWAYS CENTRAL REPAIR DEPÔT.

The second of the series of vacation visits arranged for the present session took place on Friday, June 3rd, 1910, when, by the courteous invitation of Mr. A. L. C. Fell, M.I.E.E., M.I.Mech.E., Chief Officer of the London County Council Tramways, a number of members and their friends visited the Central Car Repair Depôt at Charlton.

The site of the depôt is at Woolwich Road, Charlton, on the south bank of the Thames, and is nearly 7 acres in extent; rather more than one-half being at the present time occupied by buildings, while extension works are in progress.

The smith's shop, 130ft. by 34ft., contains two 5-cwt. electrically driven Massey pneumatic power hammers, a forging machine, a 10-cwt. drop hammer, one 6ft. by 2ft. 3in. forging and annealing furnace, and thirteen smiths' hearths. The machine shop, 143ft. by 43ft., is fitted with modern milling, slotting, screwing and drilling machines and lathes, and contains a 3-ton overhead travelling crane (3-motor type). In the wheel shop is a 150-ton wheel press, a tyre hearth, and special tyre-boring mills and tyre-turning lathes; while the truck-overhauling shop, 195ft. long by 46ft. wide, contains two 5-ton overhead travelling cranes, and has accommodation for twenty-eight pairs of trucks. Other departments include the traverser-way, inspection shop, paint shop, tool room, small gallery (containing lathes, drilling machines and small tools), large gallery (comprising the offices, testing room, plough shop, motor shop, controller shop and other equipment), and the advertisement plant, which is a steam-heated drying apparatus for paper-slip advertisements.

There are ample stores, including the tool stores, having 1,270 bins, the finished part stores with 1,750 bins, and the general stores with 6,720 bins. The power supply is by three-phase high-tension current from Greenwich Generating Station to the transformer room, where it is transformed down to low-tension current at 220 volts, and distributed to sectional distribution fuse-boxes in the works.

The heavy tools are motor driven, while the ordinary and light tools are grouped and driven by motors. With the exception of traverse motors, all the motors are short-circuited rotor 3-phase type. Lighting is effected by flame arcs throughout the smiths' shop, machine shop, truck shop and galleries, and by incandescent lamps between car-ways in the paint and inspection shops.

There is a two-storied mess-room, with kitchen on the ground floor, and a cloak room is provided, with expanded metal lockers for each employee. The premises are heated throughout by means of steam-heated units and small fans.

VISIT TO THE NEW COUNTY HALL, LAMBETH.

The third vacation visit of the present session took place on Wednesday, June 15th, 1910, when, by the courtesy of Maurice Fitzmaurice, Esq., C.M.G., M.Inst.C.E. (*Honorary Fellow*), a party of members of the Society and their friends visited the site of the New County Hall of the London County Council on the south side of the Thames at Lambeth.

The site for the building occupies an area of over five acres, of which about one and a half acres is reclaimed from the River Thames, and is bounded on the east side by Belvedere Road, and on the South by Westminster Bridge Approach.

The river is excluded by an embankment wall similar to the Victoria Embankment on the opposite side of the river. The embankment wall is founded on the London clay formation at a depth of about 20ft. below Ordnance Datum, and the whole area behind the wall is to be covered with a raft of concrete 5ft. thick resting on the Thames ballast at a level of 8ft. below the same datum. On this raft the building will be erected.

The embankment wall is being built behind a cofferdam consisting of a single row of Oregon pine piles, 14in. square, grooved and tongued, which are driven about 12ft. into the clay. The wall is of 6 to 1 Portland cement concrete, faced with Cornish and Aberdeen granite above low-water level. In front of the central portion of the future building the wall has two flights of steps leading down to the river, and the granite is finished with a rough face. Behind the wall is a series of arches forming storage vaults, and on the top of them will be a terrace, access to which will be by a flight of steps from Westminster Bridge.

Special precautions were taken in constructing the foundations of the new wall near the abutment of Westminster Bridge. The bridge is founded on cast-iron piles, and, in order to avoid any possibility of weakening this support, a length of 30ft. of the wall next the bridge was founded in a caisson, which was sunk with compressed air. The foundation of the abutment was also partly surrounded with steel sheet piling driven down to the London clay.

The embankment wall has been designed and is being constructed under the supervision of Maurice Fitzmaurice, Esq., C.M.G., the Chief Engineer to the London County Council, the contractors being Messrs. Price & Reeves. The raft foundation is being laid by Messrs. F. & H. F. Higgs, under the supervision of W. E. Riley, Esq., F.R.I.B.A., the Council's Superintending Architect, who is also associated with the Architect for the whole scheme, Ralph Knott, Esq., F.R.I.B.A.

June 6th, 1910.

DIOGO A. SYMONS, PRESIDENT,

IN THE CHAIR.

THE INSPECTION AND TESTING OF ENGINEERING MATERIALS & MACHINERY.

By C. W. V. BIGGS, A.I.E.E.

[MEMBER].

THE engineering profession has for some time recognized the advantages of standardization in manufacture, and steps have recently been made in the direction of standardizing the tests to be applied to the finished product. The application of a thoroughly comprehensive test is a lengthy process, and it is unlikely that there will not be in the covering requirements one or two clauses which cannot reasonably be made to apply, or for which the firm in question cannot provide except at prohibitive cost. The aim of the engineer is to obtain a certain article for the money, and for this purpose he must try the article before delivery; the aim of the contractor is to supply an article which shall have a ready sale, and therefore be generally suitable for a large number of conditions of working, and it is his custom to test the machines he issues, both as a precautionary measure, and also to keep himself informed of the behaviour of the machine under varying conditions, and with added improvements, as well as to keep in touch with the condition of the materials which he puts into it. The bringing into coincidence of the two requirements—the qualifications which the contractor's tests will reveal and the various additional ones which are required by the purchaser—occasionally leads to a multiplication of tests which it seems possible to reduce. In view of the very large number of sub-sections into which every branch of engineering work is necessarily divided, the compilation of a comprehensive series of tests without including requirements which, while necessary in some cases, become superfluous and vexatious in others, is, from a practical point of view, very difficult. It is, however, desirable that specifications should be as closely detailed as possible. There are also an infinite number of accessories which, while suited to the climate and conveniences of situation in one country, may become a lively source of complaint when required to do the same work in another, and these can hardly be provided for within the limits of a specification of reasonable size. The specification is therefore generally limited to pointing out the

requirements for each class of machinery, and a certain standard to be attained by the workmanship. To the inspecting engineer, as the consultant's deputy, falls the duty of satisfying his employer that the articles supplied do or do not attain this standard, giving as evidence their performance under tests, either specified, suggested by himself, or by the contractor. It is with a view to citing briefly the common requirements which can reasonably be expected from various types of machinery and the best way to ascertain that these requirements are fulfilled that this paper has been laid before this Society.

NECESSITY OF TESTING.

To keep in touch with the progress made in their manufactures and to ensure that they maintain a certain standard, the leading contractors always have a testing department, which in itself is an acknowledgment of the necessity of such investigations. From the purchaser's point of view a test is a species of invitation to the machine to break down, if it has a breakdown in its composition, at the maker's works, in preference to doing so afterwards at his own factory. As experience and the collection and study of evidence on the matter indicate weak points, these are eliminated, and, consequently, in the case of machines which have been in use for some time, the chance of breakdowns becomes less and less. There must, however, be an average rate of breakdown, altering from year to year by slow degrees: this may be called "reasonable risk." From statistics gathered by one of the leading machinery insurance companies*, a reasonable risk appears to be (taking the average over the four years 1905 to 1908) one in 9·4 for steam engines. Gas engines, as being more immature, may reduce their reasonable risk figures in the course of a few years; at present those (taken from the same source) are 1 in 10·9. Dynamos work out at 1 in 14·8, and motors, with all the ill-treatment they receive, register only 1 in 8·8. In each case about one-quarter of the breakdowns registered are classified as due to "weakness, faulty design, and workmanship," and the same proportion to "old defects and wear." The thorough testing of these machines before they leave the works should eliminate a considerable proportion of the risk of "faulty design and workmanship" as well as "old defects."

It is through the details that trouble may crop up, and the checking of these is one of the most important of the inspector's duties. Material of comparatively small value, such as lighting fittings and tramway overhead parts, on account of the careful checking required, and the danger of repeat work being rushed through, often costs in inspection an amount quite disproportionate to the value. In such cases the inspecting engineer

* The British Engine, Boiler and Electrical Insurance Co.

obtains a large measure of the blame incurred for late delivery, although he is involved in more work than he can possibly charge for.

STRUCTURAL STEEL-WORK.

The testing of plates, bars and girders for structural steelwork is carried out in a workmanlike manner by the leading mills, and presents to the inspector no practical difficulty except the one of going through a large quantity of material in a limited time. It is customary to mark a portion of one of the joists, etc., from each "pour" (or series of ingots), the piece so marked being cut to shape by the contractor, and afterwards pulled in his machine. With reasonable care in keeping the beam floating, the results given by the testing machine can be trusted. The tests in this work are fairly well established, the tensile strengths (ultimate) and elongation running as follows:—

			Tons per sq. inch.		Elongation in 8 inches.
Best Staffordshire Iron, plates					
lengthwise	21	..	6% to 7%		
Best Best Staffordshire do. ..	21	..	7% to 8%		
Best Best Best Staffordshire do. 21 to 22 ..			8% to 9%		
Mild Steel	26 to 30	..	20% on 8in.		
Soft Steel	28 to 32	..	20% on 2in.		
Hard Steel	35 to 40	..	15% on 2in.		

For structural steel, a cold bend will usually be found sufficient. Lamination is the most frequent reason for rejecting steel plates. On this account many consultants require the plates and bars to be individually examined. In the case of a large quantity of material, laid in piles, this can only be done by agreement beforehand with the contractor, as he can hardly be expected to find the space for laying out, and to devote a crane entirely to this work at short notice. Examination is made with the object of detecting unequal thickness, flaws, scaling, and, in the case of girders, deviation from the straight. It is as well to check a length in each pile, the thickness of each plate and girder, and to examine the sheared ends and sides for small cracks and laminations. Plates, etc., which pass the tests should be stamped.

Another useful test for a girder is to weigh it, the weight per yard for all sections being given in well-known tables.

Rivets will be of iron and steel of the following strengths:—

				Tons per sq. inch.	Elongation in 8 inches.
Iron, Tensile	21.5 to 24	..	23%		
Steel	24 to 28	..	25%		

and samples from the rods will require to be bent double without fracture.

BOLTS.

As well as the tensile tests, a certain number from each bag—say 5%—should be tried with the nuts, and the threads examined. The length and diameter of each size should be checked.

When the stanchions, etc., are built up, the leading length of each member of the structure should be checked by the drawings, and the position of all brackets and important bolt-holes noted. Straightness of all parts should be verified. All ironwork must be examined before painting. Any ironwork which has been bent should be examined at the bend for signs of drawing out of the metal. A nice finish depends upon neat shearing of plates, but accurate fitting of the various parts is of the first importance. In this, as in all inspecting work, it is necessary to note identification marks of each finished piece and girder; in the plate stage this is not practicable, the pieces being then described as so many 1 1/2 in. flats, 1 ft. by 12 ft., and so on.

BOILERS.

Boiler plates are tested at the rolling mills. These will be of mild open-hearth steel, having a tensile strength of from 26 to 30 tons per sq. in. and an elongation in 8 in. of 20 to 23 per cent. Pieces cut from the plates are tempered and then bent—a fairly severe test. Plates should be examined for any signs of hollow places. A certain proportion of carbon, phosphorus and manganese in the steel should be invariably asked for, but this does not come within the inspecting engineer's duties to verify. Rivets will be of open-hearth steel, of rather higher tensile strength than for structural work, viz., 26 to 28 tons per sq. in. The steel should stand bending cold round a bar of its own diameter. For tubular boilers, weldless solid steel tubes are used. They are tested with a water pressure of 1,000 or 1,500 lb. per sq. in., and 500 or 600 tubes will seldom yield one rejection. The ends of sample tubes are also expanded by means of a boiler tube expander to $1\frac{1}{10}$ times the original diameter. If the operator takes his time this can be done, but it is a little apt to be rushed, and the end split in consequence.

The hydraulic pressure used for testing boiler drums will be 50 per cent. above the working pressure for which the boiler is designed. All seams should be examined during the test.

VALVES.

Valves and similar fittings are tested for tightness of the valve and tightness of the casting at the maker's works. The pressure will be from 200 to 400 lb. per sq. in., the latter for steel-bodied steam valves. Safety valves and such fittings as low-water alarms should be tested with steam. Clack non-return valves

require steam to demonstrate their action absolutely, but a fairly good test can be made with water. Automatic exhaust valves, which open direct to exhaust when the vacuum goes off, can best be tested by means of air pressure, as they should open as soon as the suction on the underside ceases. They must be absolutely air-tight.

To get through a number of steel valves in a short time hydraulic testing must be used, with steam on a small proportion, say 5 per cent. It is not generally feasible to use steam at more than 280 lb. per sq. in., and even then the heating of the valve will cause some moisture or paint to evaporate and make it difficult to distinguish whether steam is really coming through or not.

PIPING.

Steam Piping. For high pressures, weldless steel tubing is used. The thickness of pipes should be checked whenever possible, and the thickness of flanges is worth watching. Bending these pipes requires care, in order to have it done sufficiently slowly. The operation should be watched in the early stages of the work, and the result on the contour of the bend noted. If this looks at all strained, a bend may be cut up, and test pieces pulled.

Exhaust piping, where of cast iron, can be best tested hydraulically. In such testing it is necessary to watch that no air is left in the pipe when filled. Where the pipes are tested one after another in a press there is no trouble about this, but where pipes are connected up in lines, filled from a main, and then brought up to pressure by means of a force pump, it is well to look into the matter. Where the flow is slow, and the pipe line complicated, with large and small pipes, branches and pockets, there should be a rising pipe at the far end, of the same length as the one through which the length is filled; and the water should be allowed to overflow freely from this pipe before the end is stopped and pumping commenced. Otherwise a test which should take one hour will take anything up to three, and be unsatisfactory at that. Large pipes may be of riveted steel. These are often tested with compressed air, the joints being washed over with a solution of soap, but this is a more laborious process than water testing, and it is more difficult to judge of the extent of leakage.

Cast-iron water pipes should be checked for thickness, and the dipping in a rust-preventing solution verified. They are tested at 30 to 50 lb. per sq. in., to make sure that no cracks occur. Branches and position of bolt-holes in flanges should be checked from the drawing. To do this the whole line should be assembled before leaving the works. This applies to all large piping which is not merely a repeat, as in cast-iron drains.

CONDENSERS.

In surface condensers the body will be tested hydraulically before the pipes are inserted. The tubes, where of solid drawn brass, require to have pieces cut off as samples early in the work, which pieces should be submitted to a metallurgist to make sure that the tubes have not been drawn through at too great a rate, with consequent heating and deterioration of the metal. The tubes will be tested by hydraulic pressure at the maker's works. When the tubes are assembled, hydraulic pressure is again applied, inside the tubes, for a quarter of an hour, if possible, the inside of the condenser being examined through a manhole, or by removal of the end cover, for any signs of leakage.

STEAM ENGINES.

In large steam engines it is worth while taking test pieces from all the leading parts at the foundries and forges, to check the composition of the metal before any machining is done. This will include the cylinders, pistons, piston-rods, connecting rods, and crank-shaft. In large turbines the main shaft cannot be too minutely tested and examined for flaws. Since it has become possible to shorten this shaft in relation to its diameter, less trouble is experienced from blade-stripping, but the breaking of a shaft at turbine speeds is a matter worth taking every precaution against.

The main crank-shaft of a reciprocating engine will be of mild steel with a tensile strength of 30 to 34 tons per sq. in., and an elongation of 26 per cent. in 2in. The main contractor usually sends an assistant to the forge to check dimensions, otherwise it would become the inspector's duty to verify these, and the angles of the cranks as well as the throw. On the finish of the shaft the oil-ways should be examined for any signs of internal flaw.

For large castings all that can be done is to watch the nature of the material put into the furnace, and see that inferior pig, or broken-up wasters are not used. Anything like serious blowing during the pouring would be bound to show in the casting. It will be well to witness the pour as slight blowing might not give external evidence of its occurrence.

In the case of small high-speed engines it is not amiss to check the horse-power from the diameter of the cylinders when these are first finished.

Crucible steel, when employed for piston-rods, will be the object of considerable attention, and it will frequently be found on testing to be too hard. This material may be made up to 50 tons per sq. in. tensile, but the limit usually asked for will be 38 to 40 tons per sq. in.

The principal test asked for will affect the finished machine. This is usually run for six hours and, in the case of large sizes, the steam consumption is taken by measuring the condensed steam in a weighing tank. Engines (condensing) over 1,000 B.H.P. are now made with a steam consumption of 18 lb.* per kilowatt-hour, and of 100 B.H.P. upwards with a consumption of 26 lb. per K.W. hour. These figures are for effective load at the generator terminals.

At the end of the test runs the temperature of the crank-chamber oil on enclosed high-speed engines should be noted. After steam consumption trials it is advisable that the engine be opened up and all working parts examined.

ACCUMULATORS.

In country house installations electric accumulators can seldom be dispensed with, and are usually found economical in small stations where a rapid increase of load cannot be anticipated. To test a whole battery, a steady load must be furnished, if necessary artificially, by means of plates in a tank containing acidulated water. This load will be maintained for 6 or 8 hours, according to the output of the battery, the specific gravity of the dilute acid in the cells being taken with an hydrometer, and the volts noted. Per cell, the pressure should be, just after the charge 2.6 volts, falling rapidly to 2.2 or 2.1 volts under load, and then more gradually to 1.8. If this point is reached before the full discharge for which the cells are rated, these will not do the work required of them. It is important that the acid to be used in accumulators should be free from all metallic impurities, particularly arsenic, copper, zinc, and iron, as well as from nitric or nitrous acid.

GENERATORS AND MOTORS.

Electric generators or dynamos depend upon two points—insulation and rigid construction. The design of a dynamo or motor is a matter which can be left to the contractor, as in these days thorough solidity of the rotor or armature is the rule, and exceptions are extremely rare. Brush gear should be looked into, and a sectional drawing of the commutator may be asked for. For materials, machined parts of all castings should be examined. This particularly applies to rotor spiders, which are frequently faulty. The works may be left to take permeability and hysteresis tests of iron for armature, rotor, and stator stampings. With good modern silicon steels any trouble due to heating is far more likely to be due to the designer having cut his iron too low or to “burring” of the plates during erection than to the intrinsic properties of the material itself. The built

* *Engineering*, March 25th, 1910.

up stators of large motors and generators should be examined before winding commences, particularly in the case of machine with partially enclosed slots.

After making sure that the insulation is thoroughly satisfactory and of sufficient thickness, and that the coils are being carefully wound and not maltreated, the inspecting engineer has little further to do on small machines until they come up for final test.

For all large electric high-tension polyphase generators where former wound coils are used, each coil should be tested at three or four times the working pressure before issue to the erectors. It is instructive also to take one coil per one hundred and actually break it down. The various parts, such as the rotor or armature spider, and the outer ring of the alternator are carefully examined for flaws, preferably during machining. On final test, the inspector will make sure that the dynamo or motor runs the required way round (apparently it would be impossible for mistakes to occur in this, but they do), that the speed is correct and pulleys and shaft of required size. The machine will be run six hours at full load (if an alternator, preferably at 0.80 power factor), and the final temperature of the hottest part taken.

Heating tests are of importance. For foreign work, each motor should be tested, as it is no uncommon thing for five out of six motors to come within specified temperature limits and the sixth to exceed. As regards rating, crane motors should be reckoned on the result of one hour's run on full load. Continuous rating is reckoned by the Engineering Standards Committee as six hours' run at full load, with a maximum permissible temperature rise of 40 deg. C. Or to save time such motors may be tested for four hours only, the first two at 20 per cent. to 25 per cent. overload, and the remainder at full load. This has roughly the same effect. The efficiency is also usually specified. This can only be found satisfactorily, in the case of motors, by the use of a brake, but these are not always available. Otherwise it must be calculated from the resistance of field and armature windings when hot, together with a measurement of the watts required to drive the motor light at its rated speed. This is practically the only method for taking the dynamo efficiency, as these machines, when tested, are usually driven by shop motors whose efficiency is unknown. The load is checked by means of instruments on the dynamo terminals. The current generated is usually dissipated in water resistances. Two dynamos may be tested together economically by means of the Hopkinson test, where one machine drives the other as a motor, one being then a little over-loaded. It is a good check to plot the open circuit and external characteristic curve from particulars taken on test. This should be done for one or two motors out of a large order,

to check against curves supplied by the makers, and ascertain that no important variation has taken place since these were issued.

At the termination of a six-hour test, motors and dynamos are usually "flashed," that is, they have a pressure three times the rated working pressure passed through the windings for one minute, while still warm, with a view to locating any weak points which may exist.

ALTERNATORS.

On all alternators the no-load excitation curve and short circuit characteristic need to be taken. It is advantageous also on alternators having open-slot stator stampings to obtain the sine wave by an oscillograph or by an ondograph. In some cases, owing to the size of the alternator or the method of driving the same if by a large engine, full load trials are impossible. Some idea of the iron heating may be arrived at by running the machine on open circuit over-excited until constant temperatures are reached. The exact amount of excitation employed is that necessary for full load at 0.8 power factor.

ELECTRIC CABLES.

The tests for electric underground cables are amongst those which have been standardized by the Engineering Standards Committee. Paper insulated cables should have the paper occasionally tested for tensile strength and be submitted to microscopical examination to ensure absence of adulteration of the wood pulp. Vulcanised india-rubber cables should be tested in core stage. For cables critical tests are those on completion of copper resistance, insulation resistance, and pressure test, as per the Engineering Standards specification for polyphase work. Paper cables for polyphase work should be tested for capacity.

Cables require less interim inspection than any other material, but the failure of the V.I.R. cable under pressure test is a frequent occurrence. The final test is usually immersion in water for twenty-four hours, after which a pressure test is applied for half an hour. Subsequently the insulation resistance of the copper to earth is taken, and the resistance of the copper itself. The cable test is interesting as being one of the few electrical tests whose first principles are fairly evident. A high insulation resistance may mean that the fibre surrounding the cable has been baked to the limit of cohesion, and is ready to crumble when the cable undergoes the rather strenuous treatment of "drawing in." A newly laid cable has been known to give a good test, and go to earth a week later with considerable thoroughness, selecting 10.0 p.m. as the time to do it. Considering what very high resistance values can be obtained from a comparatively thin coating of insulation, when dry, the presence of a nail sticking

through the tape, or other small mishap of the kind need not be remarked until the moisture which has found its way through begins to deteriorate the cable. It is a distinctly pessimistic view to take of this test that it is only an indication when it is bad, but with work in the ground that is very often so. A more satisfactory test is the pressure test.

There is a great deal in seeing the manufacture of cables. Let the engineer go over the works when the order is given, and see the various processes, and obtain samples of the material used. He will then be able to judge if the customer is getting a well-made article. The final tests, for copper and for capacity, are useful as records.

Bare copper wire is tested for tensile strength and conductivity. The sizes most in use for tramway purposes are 0000 and 000, having a diameter of 0.46 in. and 0.409 of an inch respectively. These should have a breaking load of 3.5 tons and 2.3 tons (for hard drawn wire), or 21 to 22 tons per sq. in., with an elongation of 3 per cent. in 10in.

Trolley wire is frequently made with a groove to allow of the use of gripping ears instead of the soldered ones. There are four or five different sections in use, which seems unnecessary, and will probably receive the attention of those interested in standards. The groove for the wheel is standardized.

OVERHEAD TRAMWAY FITTINGS.

These require special attention in inspection as it is not practicable to submit them to any special tests, and, being small repeat work, they are apt to be rushed, and wanting as to finish. This does not apply to repeat work in the shops of a good firm, where the very repeating has been recognized as indicating the introduction of a special machine tool for finishing which treats all parts precisely the same. It is where a large quantity of small castings is required that there is danger of a low-priced tender and consequent poor metal.

In consequence of these drawbacks it is necessary to examine such castings; firstly, for quality of the metal, and secondly, and minutely for workmanship and suitability. Where the castings are presented in odd batches of two or three hundred at a time, this individual examination increases the cost of inspection, but is unavoidable if future annoyance from bad fit and workmanship is to be avoided.

GALVANIZING.

Attention should be given to galvanizing in view of the large amount expended on galvanized fittings for telegraph and telephone lines, for pipes, tanks, and overhead tramway fittings. The E.S.C. test of plunging into a saturated solution of copper

sulphate at 15.6 deg. C. for one minute, withdrawing, wiping dry, and again immersing for a total of four times without shewing any sign of a reddish deposit of copper, is an eminently fair one. Very few articles galvanized by dipping into zinc spelter call for rejection. With dry galvanized or sherardized articles, this test ensures that the pure zinc layer (which should exist outside the zinc iron layer) is adequate.

Strain insulators can be tested both for tension and insulation. The strains and voltage which they will stand are usually given by the firm supplying them.

The insulators used between sections on the trolley wire, which are connected with plug switches on the pole, are usually short in the break.

Trolley poles (*i.e.* the pole on the top of the tramcar) are tested by hanging a weight on the end of the pole, say 50 lb., and noting the deflection. There should be no permanent set. A 2in. to 1in. pole 13ft. 6in. long will deflect 15in. under this test. The base of the pole should be examined to make sure that it may be reversed without danger of catching or fraying the conductor which runs down it.

SWITCHBOARDS AND SWITCHGEAR.

Switchwork is liable to one main defect, that is that the copper or brass screw passing through the board, to which a cable has been connected on the other side, is apt to be too small. It is then impossible to tighten up the lug of a heavy cable sufficiently well to make good contact without risk of screwing off the end of the connection. Small cables, which are fairly flexible, do not put this stress on the connections. The sectional area allowed for the rubbing contact of switches is generally ample, and if there is going to be any trouble with these it will be at the joints. Fuse boxes only need testing when designed for use on high-tension circuits; otherwise inspection for workmanship will suffice. In dealing with switchboards it is usual to flash them with a high voltage, that is, to connect all the current-carrying parts of the switches, etc., to one pole of a high-tension testing circuit, and the framework of the board to the other pole; this will bring out any weak point in the insulation.

On high-tension switchboards the carriers and back connections for the cables consist of or necessitate the use of porcelain insulators. While the porcelain insulators used for telephone and telegraph work call only for an examination as to glazing, and a red ink test as to porosity, the porcelain insulators used for high-tension transmission lines and high-tension switchgear are very important items. The author is indebted to Mr. J. F. C. Snell, M.Inst.C.E., for permission to quote his require-

ments in this respect. This specification requires that all insulators should pass the following test :—

- “(a) The insulators to be made from the best hard-fired English porcelain, thoroughly vitrified and non-hygroscopic.
- (b) The glaze to be continuous throughout. Each insulator to be uniform, acid and alkali proof, and delivered and erected free from all flaws, cracks, bubbles and chipped edge. Any faulty insulator to be rejected.
- (c) The corrugations (or internal threads, if any) in the insulators to be uniform and cleanly moulded.
- (d) Sample insulators, taken at random from a batch, to be broken into small pieces, and accurately weighed after being kept in a drying oven for 24 hours.
- (e) The pieces (obtained as in (d) above) to be then immersed in water for 24 hours, and after being carefully wiped to be again weighed. If the samples show any increase of weight through absorption, the consignment from which they are taken to be rejected,
- (f) Each insulator to be immersed in water for 48 hours the surface dried and subjected to a test pressure of three times its working pressure for one hour without breaking down.
- (g) Each insulator to be subjected to a mechanical test by applying a weight to the extremity of the insulator when fixed at its base or on its pin, so as to give a side strain of at least four times the normal load it is required to carry.”

Meters and measuring instruments are checked against standards at various points of the scale, or, in the case of wattmeters, are run for a certain time at stated loads. The accuracy of these meters is very apt to be questioned, and, therefore, in the case of large quantities, the standards themselves have to be checked up occasionally. The insulation of power station meters, including their transformers, must be carefully watched. Cables used in the power house should be fireproof, the fireproof qualities being tested from samples taken at the works. The switch panels are of marble or slate. Marble and slate must be examined for metallic veins. These are difficult to locate without cutting into the slabs (which is impracticable). The slabs should therefore be soaked and tested with an ohm-meter across the doubtful parts. The chambers for high-tension apparatus are made of fireproof brickwork or some form of cement work. Pieces of this should be tested in an electric arc to see if it disintegrates.

MACHINE TOOLS.

Lathes are usually specified to take a certain diameter and length of work. Where a drawing is sent with the tender the checking is a simple matter, otherwise the inspector will generally have to be contented with his knowledge of such machines to pick out the weak points, if any. Machines doing heavy work, subject to shocks, such as shapers and shears, are the better for a short run, taking the highest performance that the machine is rated for on its description. The size of driving pulleys should always be verified.

CRANES.

Cranes will be tested with an overload of from $1/4$ to $1/3$ the rating, which should give no permanent set, and a deflection limited by the material and type of crane. In testing cranes driven by electricity, note the current used by each motor to see if it is in excess of what is required for the work performed. Crane motors must be tested to a considerable overload, as the starting effort is much greater than the working, and so frequently repeated. The overload, however, need not be applied for more than four or five minutes. At first sight, to ask for, say, a 25-horse power motor, which is to stand a 50 per cent. overload, *i.e.* to develop $37\frac{1}{2}$ -horse power, appears to be a roundabout way of asking for the larger motor. Where, however, the overload is only applied for a short time, the requisition is rather for type than size. A motor to take heavy overloads need not be of the larger size if the mechanical construction is good, the brush area large, and the iron in the fields ample. Insulation must also be of the first quality. What can be done in the way of overloading is evidenced by the tramcar motor, which works practically under crane conditions, but with even greater number of "starts" and for a period varying from 12 to 17 hours per day.

In a brief survey of some of the methods by which machinery is tested at the present time, it is evident that a number of important branches have been overlooked. The subject of internal combustion engines, for instance, would more than absorb a paper to itself. It is hoped, however, that the notes which have been incorporated in this paper may serve to draw attention to the question of indispensable, as opposed to avoidable tests, and contribute towards the adjustment between the two which must be desirable to every member of the profession.

APPENDIX.

OFFICE EQUIPMENT.

It is mainly in regard to electrical plant and materials that the inspecting engineer, if his work is to be done in a thorough

manner, must maintain a number of standard instruments for the purpose of checking the calibration, or extending the number of those available in any of the works he may visit.

For direct current work, a combination of a millivoltmeter with a suitable number of shunts and of series resistances, such as are made by a large number of instrument makers, suffices for any ordinary range of work.

For alternating current work, a combined voltmeter and ammeter in a common case, with a separate box of current transformers, can be obtained at a reasonable price to give ranges up to 75, 150, 300, and 600 volts, and ranges 5, 25, 50, 100, 250 and 500 amperes. The range can always be extended to cover larger current capacities by purchasing more current transformers. It is desirable also to add a pair of indicating wattmeters; one with its current coils calibrated for use simultaneously with the ammeter on the same current transformers, and the other with a separate box of current transformers.

Recording volt and ampere meters are often valuable on such work as crane tests, but their initial cost, dead weight, and cost of repairs, due to transit damages, render them a luxurious refinement rather than an essential item of equipment. They are likely to prove of special service when the engineer does not wish to spend the entire six hours on the test bed, but desires to inspect progress on other machinery being made in the works. Under these conditions his recording instruments will tell him how the test loads have been maintained in his absence.

The megger is indispensable. The engineer should take one for electric crane tests and the like, to ascertain that no injury through damp has occurred in transit.

A good portable moving coil pointer galvanometer with a box of shunts or series resistances serves a number of uses. With a D.C. supply at the works it can be used to measure insulation, while calibrated with certain thermo-couples it permits the measurement of temperatures at points out of the range of the ordinary thermometer.

On all A.C. generators, the E.M.F. wave should be obtained by either an oscillograph or an ondograph. The use of the latter is best confined to generators running on open circuit or on a dead steady load.

A conductivity tube and conductance meter are useful accessories on all steam engine trials as affording tests of boiler priming or condenser tightness which may give results against the engine builder.

The steam engine indicator may be needed at any time.

The same does not appear to apply to the steam calorimeter.

Standard speed counters, preferably of the combined chronometer and counter pattern, are very accurate and can be used to check the ordinary speed counter fitted to engines.

Thermometers, both standard, reading to $1/10$ of a degree Centigrade, and commercial, reading to 1 deg. C., are necessary. In using a thermometer to measure any surface temperature the mercury bulb should be encased in lead foil. The bulb being cylindrical can only make a straight line contact with, say, a commutator. By enshrouding it in lead foil, the heat transmitted, while only virtually through a straight line at the heated medium, gives a quicker and often higher reading. Of course, the bulb needs to be further shielded by cotton waste.

On all repetition jobs the works are, as a general rule, excellently equipped with limit gauges. For larger jobs like large cylinders, a set of inside micrometer gauges is of use to the inspecting engineer.

In regard to equipment which is purely for office and laboratory use, the inspecting engineer must decide for himself as to how much of this work he can undertake, and whether he desires to carry out any research work on the properties of materials. While a certain amount of chemical knowledge is necessary to the inspecting engineer, analytical work should always be undertaken by a trained chemist. Much can be done, and more ought to be done, by co-operation with those employed in parallel branches of scientific work. A certain number of physical tests can always be carried out by the inspecting engineer, such as the determination of the specific resistance, viscosity, flash point and specific gravity of oils; the ascertaining the time of setting, expansion and tensile tests of cement; the photometry of incandescent electric lamps; the decay of insulating materials, the pre-determination of the likelihood of corrosion; tensile tests of fabrics, and so forth. Indeed, the question is almost at what point the inspecting engineer should stop.

A few simple re-agents, a balance, and a good microscope cannot be dispensed with. There is much the inspector must always refer to the specialist, but the intelligent use of a certain amount of apparatus saves constant recourse to the specialist.

DISCUSSION.

The President moved a vote of thanks to Mr. Biggs for his paper, with regard to which he would like to make a few remarks.

He quite agreed with what the author had said about specifications being closely detailed, but it must not be forgotten that in some instances it was necessary to frame them as widely as possible. With regard to breakdowns, etc., the author stated. "In each case about a quarter of the breakdowns registered are classified as due to 'weakness, faulty design, and

workmanship,' and the same proportion to 'old defects and wear.'" He wanted to know what had become of the other half. Under the heading of "Structural Steelwork" the author had not mentioned contraction of area, which in his opinion was a very important factor in the testing of materials. There were no results of compression stresses, and there was no reference whatever to cast iron, which in special cases was a material often used by the engineer. With regard to piping the author said "cast-iron water pipes should be checked for thickness, and the dipping in a rust-preventing solution verified. They are tested at 30 lb. to 50 lb. per square inch, to make sure that no cracks occur." He would like to know how these figures were obtained. It appeared to him that this value would vary according to how the pipes would eventually be used, in other words with the hydrostatic head which came on the mains. The author also stated that "where the flow is slow and the pipe line complicated with large and small pipes, branches and pockets, there should be a rising pipe at the far end, of the same length as the one through which the length is filled." On that assumption the hydraulic gradient of the pipe would be at an angle of about 45 degrees. Supposing the hydraulic gradient was at 30 degrees, the rising pipe would then not be the same as the length filled. Perhaps the author would explain this in more detail. He regretted that the author had not referred to copper and rubber which were very important materials, and largely used at the present time.

The vote of thanks was carried by acclamation.

Mr. W. G. Kirkaldy said that he thought that the paper was very complete, concise, and useful. With regard to the elongation of steel under tensile stress, he thought that 20 per cent. was a very small extension on a length of two inches, and that the length given in the table should be 5in. instead of 2in. He was in sympathy with the President's remarks about the contraction of area. Contraction was a more drastic test than elongation, and it revealed defects more markedly.

He would like to endorse what the President had said with regard to cast iron. He thought that a little data on that point would be an advantage. One of the best tests was the ordinary transverse test. He recommended a bar 1in. wide and 2in. deep, tested upon a span of 36in. as a good standard. It was as well not to introduce other sizes if it could be avoided.

Referring to cast-iron water pipes the author said that they should be checked for thickness and that they were tested at 30 lb. and 50 lb. per square inch. A good deal depended on what they were tested for and the size of the pipe; but it seemed to him a very low proof test. He thought that in many cases it would not be enough to bring out the presence of defective

parts. Each engineer must watch the particular work in hand. Personally he would like to see the test pressure a good deal higher.

In the case of tramway fittings he thought it a very important thing for inspectors to watch the shape. He had seen cases where the metal had been of excellent quality, but the pattern had been badly designed. A certain neck or section had vitiated the whole article. A little attention to such points might run up the strength of the fitting 50 per cent. without more metal. If a contractor took pride in his work he would follow such points himself, but if he did not the inspecting engineer must keep him up to the mark. As the author had touched upon the testing of steel work he might mention one point in connection with it. The aim of some managers of works was to get as much material passed as possible, and as few rejections as they could. That was only human nature. He had had a good deal of trouble on that account, and an inspecting engineer needed to keep his eyes very widely open to see that the works tests were reliable.

Mr. Henry C. Adams said that although one might not be engaged in the work of an inspecting engineer, any engineer was liable at any time to be called upon to visit works and inspect different materials in the course of manufacture. It was to his mind equally important to standardize the test as it was to standardize the material because there were so many tests called for, some of which the author had enumerated, that were quite unnecessary and were irritating to the manufacturer; and if such tests were insisted upon by the engineer they would probably cause an upset at the works and necessitate special arrangements being made to turn out the work for one particular client. That would be altogether bad.

With reference to the risk of breakdown in steam engines, the ratio of 1 in 9·4 under test was very high, and if it was correct it reflected very great discredit, in his opinion, upon the manufacturers. He noticed that no reference was made in the paper to breakdowns by improper use. He thought that there were many machines which were broken, and eventually worn out by improper use, and perhaps the other half of the breakdowns, of which the President had spoken, was accounted for by that.

With regard to the test pressure for water pipes, he suggested that water pipes were peculiar among the materials used by engineers, inasmuch as they were not designed in the ordinary way for the work which they had to do. They were invariably made far thicker than necessary, and although 50 lb. might be all right as the working pressure test, it was totally out of proportion to the thickness the pipes were made. He thought at first that a figure "2" had been dropped out, and that what was

meant was not 50 but 250 lb. to the square inch. He thought that 200 lb. to 250 lb. was a fair figure for testing water pipes.

With regard to inspecting large castings for steam engines, Mr. Biggs was putting a lot of work upon the inspector if he had to watch the material put into the furnace and watch the casting poured, in addition to making the ordinary inspection and tests after the castings were in existence. He would like to know whether that was usually covered by the ordinary fee for inspecting machinery during the progress of manufacture.

He did not understand the paragraph about high-speed engines where it stated that the horse-power should be checked from the diameter of the cylinder. The diameter of the cylinder might be checked, and it was a very important thing to check, but he did not know that the inspecting engineer had very much to do with the horse-power, or how he could get at it from the diameter of the cylinder without knowing other particulars. It would be getting back to the old "nominal horse-power," which was being discarded as a useless term.

With regard to tests for porcelain insulators, they could not very well criticise Mr. Snell's specification in his absence. But perhaps Mr. Biggs could give some information on one or two points. The fourth clause read: "Sample insulators, taken at random from a batch, to be broken into small pieces, and accurately weighed after being kept in a drying oven for 24 hours." He should think that the material might be dried in very much less time than 24 hours.

With regard to the immersion test it was stated that if the samples showed *any* increase in weight through absorption they were to be rejected. That was a very stringent regulation, and he would like to know whether in practice Mr. Biggs found that the insulators actually came up to it. He should think that there must be some absorption even if it were very small. In drawing up the specification, such a regulation might be put in as one of the ideals which they would like to reach, but he thought that in practice a little less should be required. In testing other materials, for instance, bricks, where a 24 hours' absorption test was generally used, he had tried boiling them for 20 minutes, and subsequently allowing them to cool down in such water for $2\frac{1}{2}$ hours with the result that he had found that if a brick absorbed say 8 per cent. in this time, it could be left for three or four days afterwards and it would not add as much as another 1 per cent. to that figure, which showed that 20 minutes boiling was for all practical purposes equal to 24 hours plain soaking.

Mr. E. H. G. Brewster said that he was very interested to hear Mr. Adams's suggestion for the testing of bricks by boiling. Soaking bricks in water was very old, but boiling them was to him a new idea, and one that he certainly should adopt in the

future. He would like to enter into an eulogy of the paper, but he thought that it spoke for itself.

It was his practice in testing boiler plates to take samples of each plate from one end, and one side, and test both. Unless each individual plate was tested there could not be a certainty that equality was obtained. If one or two plates were harder than the remainder, and were not rejected, the result would be that when they were made up into the boiler too great a strain would be thrown upon them, as they would not be of the same elasticity as the other plates, and in consequence they would be likely to cause a fracture.

With regard to what had been said about the necessity of taking the angle of cranks, and so on, in connection with engines, that was of the highest consequence. He had had to deal with a couple of small marine engines which drove a particular kind of propeller by means of coupling rods attached to cranks on a counter-shaft. It was a new invention, and the manufacturers said that it would not work. He examined the engines, and found that the angles of the cranks were wrong, the cranks had different throws, and the coupling rods were of different lengths. With regard to locomotives it was of the utmost consequence that the coupling rods should be of exactly the proper length, because, if there was only a very small error in the length, there was a binding at the bearings at every revolution. In the case of a pair of horizontal engines he examined in the Midlands, he found that the cranks were of different throws, although they were supposed to be a pair, the difference amounting to very nearly half an inch. The stroke was about 4ft. 6in. The assistant manager of the works was utterly ignorant of the fact when the speaker pointed this difference out to him. The very next taking up of the wear of one of the bearings would probably have caused the bottom of the cylinder to be knocked out, or if that did not happen, there must have been a very large space at the end of one of the cylinders, causing a great waste of steam, and consequently an excessive consumption of fuel. It was always advisable in examining cylinders to take off the covers, because they might be in a very bad condition inside. The pistons might be working with a very considerable amount of clearance, not only at the ends but at the sides. Then again the walls of the cylinders might be badly scored and worn into hollows. In the case of a good cylinder properly lubricated, the inside should have a polished surface.

With regard to testing shafting, it was very difficult to discover a flaw in a polished shaft. He had known a case where a piece of metal had been let into a bright shaft to cover a flaw, and the work was so well done that the eye could not detect it. A very simple way of detecting a flaw in a bright shaft which was not generally known, was, to rub the shaft all over with black

grease, and then carefully wipe it off, and give the end of the shaft a succession of hard blows with a hammer, when if there were a flaw it would show itself by the black grease which had got into it exuding, owing to the jarring caused by the blows of the hammer. In some cases by no other means could the faults be discovered.

With regard to lathes, and other tools ; they could buy a 6in. lathe or a 12in. lathe at almost any price, but there were lathes *and* lathes ; some were absolute rubbish, and the same could be said of other tools. The Whitworth lathe was a beautiful machine, and very well worth the money it cost.

With regard to the thickness of the pipes, to which other speakers had drawn attention, it seemed to him that the pressure test on the pipes should depend on what the pipes were wanted for. He had had to deal with the testing of pipes ; in one case the pipes were well moulded and cast, but they erred on the side of lightness of weight. A second batch was tested, and the weight would have been correct, had the contractor not added 6in. to the specified length of the pipes. Another case the pipes were of excellent quality, but the sockets had been made just too small to take in the beaded spigot ends.

Mr. H. C. H. Shenton said that he had known a considerable amount of trouble in connection with pumping machinery. He would like to know whether any makers were in the habit of providing some sort of test for deep-well pumps before they left the works, which would discover those defects which, although trivial, caused an immense amount of trouble by not being found until the pumps were fixed. There were small errors which could not possibly be detected by ordinary inspection, but which became apparent directly the pumps started working. He should think that it would not be very difficult for manufacturers to provide a well in which pumps could receive a preliminary trial before being sent out.

Mr. Arthur Valon said he had no intention of criticizing the paper in detail, as although the subject was a most important one, he had been mostly occupied in the branch of the profession which did the specifying and not the inspecting. Members who had taken part in the discussion seemed to find it difficult to understand why cast-iron pipes were so much thicker than was necessitated by the pressure to which they were likely to be subjected ; but those who had to deal with branches of engineering in which a large amount of pipe work had to be done understood perfectly that the thickness of a pipe was dictated, not so much by the pressure which it had to stand, but by the fact that it had to stand it for fifty or sixty years. The pressure to which it was subjected in testing really had no relation to the working

pressure which it had to bear. The question was one of length of life, and not of the actual pressure at any one time.

Mr. R. St. George Moore said that the question of testing was a very important subject, not only to the testing and inspecting engineer, but to the consulting engineer. The point that they had to consider was how much they should test. The test must be sufficient to prove whether the article was good, but not sufficient to irritate and annoy the contractor. The notes that had been put forward by the author were excellent, but if they were all enforced every time, the prices of materials would be considerably increased. It was well known in Westminster that there were engineers whose specifications required such an extraordinary amount of testing, that contractors charged extra for complying with them; still, tests ought to be ample.

As to water pipes, they all knew that if they had a working pressure of 300ft. head, a stronger pipe was wanted than with a working pressure of 20ft. head. He laid about forty miles of pipes in China, and they were all tested to 600ft. head.

Mr. D. C. Graham said that one point in regard to the testing of cast iron had not been referred to at all, and that was testing it with a hammer. It was a rule almost hopeless to attempt to get satisfactory results by testing under water pressure, unless they went to very excessive pressures. There were numbers of castings also in which any weakness due to blow holes could be revealed only by going over them carefully with a hammer. In his opinion more could be done in that way with pipes than by water or oil pressure tests, which were very expensive, especially when the pipes were large.

It was also a difficult thing to know what to do when one had a large pump or something of the sort under hydraulic pressure, and saw a slight weep in one or two places in it. The specification possibly said that on any sign of leakage through the casting it was to be condemned, but if one rigidly complied with that one would have to condemn a very large number of castings. In all probability the leakage was most trifling and the contractor would inform you at once that it would rust up and be of no consequence. On one occasion he had to test a large pump that had a very slight leakage of this kind. He passed it, and it went out to China and a year afterwards the engineer out in China wrote and said that he wished to know what tests it had undergone, and who had tested it. It appeared that after the pump had been working for about a year it developed a crack right across, and it was then found that there was what is called a spongy place of a length of about 2 or 3ft. across the casting, but at the test there was absolutely nothing to show that beyond the slight weep mentioned. There was some fuss about it, but he, the speaker, still thought that this was not a sufficient reason for

condemning it. There were two pumps for the same engine, and the other one had also a very slight weep in one angle, but there had been no trouble with that pump. He had never seen or heard of any test that was satisfactory for iron castings, except the hammer test, and even that failed at times.

Mr. E. H. G. Brewster, adding to his previous remarks, said that there was a very well known test for pipes, and that was to hammer every pipe with a heavy hammer, the idea being that the jarring would correspond to the jarring caused by heavy traffic passing over the pipes. It was necessary to be very careful in testing the sockets and spigots. It had been his unpleasant duty to reject a yard full of pipes because the spigot ends would not go into the faucets by $1/16$ th of an inch. If he had not been very careful to have a gauge made, he should not have found it out. Everything else was in perfect order. The pipes were coming from Scotland to the South of England, and the meeting could imagine what would have been the result if he had neglected to take the slight care required to see that one end would go into the other. It seemed almost an absurdity to test for a thing of that kind, but it was not advisable to allow anything to escape. They could not be too particular about examining everything in the most minute detail.

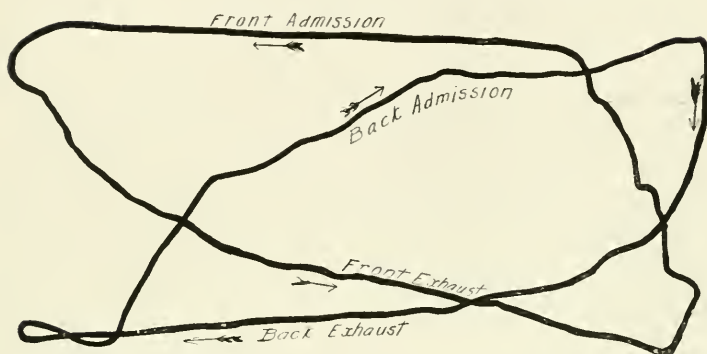
Mr. E. F. Law said that he was not an engineer but he could appreciate the paper, and he would like to add his word of praise of it. He would like to repeat what Mr. Kirkaldy had said with regard to the contraction of area. He agreed that it was a most important item.

Mr. Biggs had referred to the analysis of boiler plates, and said that a certain proportion of carbon, phosphorus, and manganese in the steel should be invariably asked for. He thought that the author had inadvertently missed sulphur, which really should be added, as it was a frequent source of pitting in boilers.

In these days of steam turbines, bearings were rather an important point, and he thought that Mr. Biggs might say a word or two with regard to them.

Mr. A. S. E. Ackermann explained the indicator diagram illustrated in the figure below. He said that it referred to an old engine which was tested in the East End of London some time ago. The people to whom the engine belonged boasted that they had not had an engineer on their premises for ten years ! The engine was one of a number scattered about a large works. Having taken the diagram, he could hardly believe that it was correct, and consequently took several to make quite sure. The engine was an old-fashioned one. The "D" slide valve was loose by about an inch on its spindle. In addition to this, on removing (with difficulty) the back cylinder cover he was able to pass his two-foot wooden rule from end to end, past the top of the piston !

I.H.P 21.73"
Revs 56 pm
Boiler Press^e 42½lb



No mention had been made in the paper of automatically drawn load-strain diagrams in connection with tensile tests. In commercial testing there was no time for such apparatus. This was unfortunate, as the area of the diagram gave the work done in breaking the test piece, thus taking into due account both the ultimate strength and the ductility of the material.

What one came across in inspecting was really astonishing. He had found tin used to fill a crack in an angle iron, where it had been bent round and cleaned up with a rough file after leaving the forge. He asked the makers whether the angles had been bent cold or hot. The answer was "Hot." He said, "Evidently not hot enough to melt the tin."

With regard to boilers, the deflection of the ends of boilers was rather an important thing where the ends were flat. In making the hydraulic test it was necessary to leave the pressure on and to disconnect the pump, so that in case one did not happen to be looking, the man in charge of the pump could not give an extra stroke or two to keep up the pressure. It was also necessary to leave the test on a long time to allow for the elasticity of the shell. He was astonished to see the large quantity of water which spurted out on removing the blank flange on one of the top seatings of a boiler, due simply to the elastic contraction of the shell of the boiler. Evidently there could have been a large leak without it affecting the reading of the pressure gauge. If they could not see all the places where leakage was likely to occur it was necessary to leave the test on for a long time before the pressure dropped, on account of the elasticity of the shell. Mr. Biggs practically dismissed the whole subject of steam engine and other trials in a few lines. He would like to mention

one or two results (which were certainly worse than he usually got) of trials of engines, dynamos, water pumps, and air compressors which he made where the specification was drawn by the contractor for about £7,000 worth of plant. There had been no consulting engineer for the work, and he (Mr. Ackermann) was called in by the employer at the last moment before the plant was taken over. In the circumstances the marvel was that there was as much specification as actually existed, but fortunately in most cases the efficiencies were specified, and these were the contractor's undoing as the following results show.—

The steam consumption per I.H.P. hour was specified at 25.9 lb. The actual result was 31.9 in one case. The output of the dynamos was slightly above the specified amount, and the temperature rise was 30 deg. F. lower than specified. The air compressor's working pressure was 110 lb. per sq. in. Its capacity should have been 156 cubic feet of free air per minute, but it was only 142 cubic feet. The specified indicated horse-power was 31. The actual was 52.6. The specified volumetric efficiency was 95 per cent., the actual 83.4 per cent. The mechanical efficiency ought to have been 85 per cent., but was actually only 38 per cent. ! The temperature of the air leaving the compressor should have been 100 deg. F., but it was actually 160 deg. F. The capacity of another air compressor in cubic feet of free air per minute ought to have been 56. It was actually 34.4. Of another, which should have been 76 cubic feet per minute, the capacity was only 46.8 cubic feet per minute. The volumetric efficiency of this set, which should have been 95 per cent., was only 55.7 per cent., and its mechanical efficiency, which should have been 65 per cent., was only 35.8 per cent. !

Lastly, there were some centrifugal pumps which should have delivered 1,200 gallons per minute. One gave only 936 gallons per minute ; another 941 gallons per minute ; and another 1074 gallons per minute. These results (which are only some of the whole) are particularly interesting as the contractor had drawn his own specification and settled the various efficiencies himself !

CORRESPONDENCE.

Mr. Geo. A. Becks wrote as follows :—

The subject upon which Mr. Biggs writes being one upon which I have been engaged for nearly 20 years, I may perhaps be allowed to add a few words to what he has said.

Papers such as this should, in my opinion, be rather more instructive than this one, which, so far as I am able to see, contains little more than an extract from several specifications, and statements as to what ought to be attended to in the drawing up of such documents.

The Inspecting Engineer comes in at a time when the work has been done, and as the author says, it is his duty to see that everything has been properly carried out, in his capacity of assistant to the Consulting Engineer.

There are times of course where the Inspector can effect an improvement in a finished product, but as a rule he can only attend to workmanship, and, in the case of raw material, to quality and strength.

There is a tendency in some offices to send a junior assistant or pupil to the contractor's work, to examine material and plant, which only an expert engineer should be entrusted with, and I have many times been told that these young gentlemen as a rule give an infinite amount of altogether unnecessary trouble, by wanting this or that removed, rivets cut out, tests made, and so on, although they are totally unable to gain any information from such tests. This sort of inspection may give a youth experience, but it might just as well be omitted for all the good it does.

An Inspecting Engineer should be empowered to effect modifications in detail, because many points with which the Consulting Engineer does not want to be bothered will crop up in the execution of a contract, and it is in this respect that the Inspector becomes the assistant and deputy of the Consultant.

Some merchants require the assistance of the Inspecting Engineer, because the actual purchaser, perhaps in South America, says that the material must be inspected; but I am afraid that the work is often done more as a matter of form than as a duty to their clients. For instance, I was recently asked to inspect a large railway turntable which had to be tested under a heavy load, a water tank on a high steel framing, a set of deep-well pumps and driving gear, and a long length of pipe, for which I was offered a fee of 2 guineas and expected to pay my own expenses! I afterwards found out that a firm of so-called Inspecting Engineers actually accepted the work. How could they possibly make an efficient inspection in these circumstances?

I should like to call attention to an important item which the author has not mentioned. I refer to tests of material at temperatures higher than normal, as for instance, copper when in the form of a steam pipe. There have been disastrous explosions of these from time to time. The burst pipes have been tested and analysed and not found wanting in any respect, but at the temperature of high-pressure steam, the strength falls to an alarming extent. Some years ago I designed an apparatus for testing metals under tension at high temperatures, with most instructive results, which I am not authorized to publish, but which throw light on some hitherto mysterious failures.

While on the subject of testing it might perhaps be well to draw attention to the practice of making centre punch marks

from which to measure the extension after fracture. I should be glad if anyone can suggest an efficient way of avoiding this, as it often happens that the fracture would appear to start from one of these centre punch marks.

There is so much to be said on the question of mechanical testing that I refrain from further comment, as the subject is one about which volumes may be, and have been, written.

I should have been delighted if the author had given us hints for observance when examining materials and machinery, in order to combat as far as possible the little weaknesses of certain manufacturers who are conscious of defective work which they hope may not be observed during inspection, such as the electric welding on of a piece of mild steel to a steel casting, "as a test piece," or the innocent game of laying a few piano wires in the mould of a cast-iron test bar, or putting a chill in the mould of a bronze casting, where the test strip is to be cut from, and similar guileless dodges. I think most of us have heard of the American cast-iron test bar which bent and remained bent at a considerable angle owing to the presence of a wrought-iron bar which had inadvertently (!) got in the mould.

The subject dealt with by the author is one of such a wide scope (indeed a paper could be written on each item), that I think he is very bold to tackle it in so little space.

Mr. W. Pollard Digby wrote :—

The paper before us is one which has the often highly commended defect of brevity. Had Mr. Biggs so chosen he could have presented a paper of eight or ten times the length without being in any way tedious or redundant. Therefore to us who are discussing this paper it remains rather to debate broad principles than to seize and dilate upon the possible omission of any particular test or group of materials.

I should like first to speak upon the relation of the inspecting engineer to his principal, the consultant, and to the works. The intermediary duties carried out by the inspecting engineer as the consulting engineer's deputy are in every degree as requisite as those performed by the resident engineer on any such construction work as a reservoir or dock. Certain properties and certain performances being specified, it is the duty of the inspecting engineer to see that these are provided; that is to say, he must prevent either the deliberate evasion or inadvertent omission of compliance with specified conditions. This is not the place to recite a summary typical of one week's happenings, which it would strain one's sense of charity to regard as all inadvertent. Keeness of competition counts for much.

The figures which Mr. Biggs has quoted from the annual reports of one of the insurance societies shew a high accident rate. If so many failures of insured machinery subject to periodical inspection during use occur in practice, it is apparent that much

can be done by the inspecting engineer to reduce this high rate of failure. Very roughly one-fourth of the accidents occurring are reported as due to weakness, bad design, workmanship and materials. We may therefore reckon that, of the total number, failures at the rate of $2\frac{1}{2}$ to 3 per cent. per annum of the engines and from 2 to 4 per cent. per annum of the dynamos and motors are preventable by adequate inspection.

Critics of the inspecting engineer are apt to talk about the cost of inspection, without taking into account the fact that the effects and cost of a failure throw a burden on the purchaser which is out of all proportion to the actual item failing. A mill engine breaks down, and until its repair, capital lies idle, the mill output ceases, and heavy losses accrue. A defective plate may wreck a boiler, a fractured piston-rod smash an engine, a burnt out armature coil put an armature out of use for some days, while the failure of a single current transformer on an extra high-tension system may shut down a central station, and all the operations dependent upon it. These instances could be multiplied considerably, they are only briefly referred to, as it will be apparent that if thorough inspection merely reduces the rate of failure due to defective material by one-third of its normal average, the cost of inspection is directly covered by the saving of the cost of repairing or replacing defective material, and covered many times over by immunity from the indirect losses due to failures.

Now there is the question of the attitude of the manufacturer to the inspector. One cynic has summarized this as veiled hostility tempered by hospitality. I would throw over the cynic and suggest that an intelligent and impartial inspector is in reality the friend of the works. True that the works testing department is there to deal with finished materials. But such testing departments are never too lavishly equipped, while overtime is endemic rather than epidemic. Under such circumstances many testing departments have all they can do to keep pace with the shops.

Incoming material, raw or partly finished, is not always dealt with by a testing department. The manufacturer of the final article is in the hands and at the mercy of the firm supplying the raw material, so that the inspecting engineer is not the hostile critic, but the ally of the manufacturer to whom specifications calling for materials of certain quality represent conditions to be honestly worked to. Conditions of strain are inevitable where contractors pigeon-hole specifications and are content with piously taking them as read.

The author has in a few pages covered a large ground. He has indicated rather than asserted that the work of the inspecting engineer, if it is to be of any value, must be anything but perfunctory. I would suggest that he should use his paper as the

nucleus of a book dealing with the subject. In such a book he could, I am sure, give many curious instances of defective castings, and bad designs, and discuss many of the failures coming under his notice. I realize that conditions of space have been the sole cause of the brevity of a valuable paper.

Mr. P. G. Scott wrote :—

Engineers who practise abroad have to become familiar with the materials they have at hand, such as timbers and building stones, and these will need testing to ascertain their suitability for use. They may have to manufacture certain materials, such as bricks and lime, and even cement in some cases, and these again will require testing. They will have to examine carefully articles sold in the local markets, such as paints, tools, and building materials, to ascertain their quality, and they must be familiar with the names of the best manufacturers of articles with which they have to deal. When the writer was in charge of the Public Works Department Central Stores Dépôt at Rangoon he had to receive materials and machinery sent by the India Office for the use of the Public Works Department according to the regulations of that department. The code rules are that all articles of European manufacture have to be indented for from England, through the Stores Department of the India Office. When the stores of European manufacture run short, and are required urgently by engineers in the Province, the engineer in charge of the Stores Dépôt has to make such purchases locally as well as the usual articles of local manufacture; these articles consist principally of various kinds of tools, building materials, and machinery, and require careful inspection as regards quality, shape, size, and weight. A few cases may be mentioned to show what care should be taken; for instance, in testing the gauge of corrugated iron and other metal sheets, the test by a gauge measure is insufficient; a certain number should be weighed, and an average struck for the thickness of each sheet and compared with the result obtained by the gauge measurement. In one case a certain number of galvanised iron standards for fencing were supplied, and on inspection were found to be of irregular sizes. Again, indefinite orders often lead to deplorable results. For instance, an engineer indented for a certain size of rope, but it was not made clear whether the size referred to the diameter or the circumference of the rope. The engineer who gave the order, being located at some distance from the stores, the order had in the interim been passed through, with the result that the wrong size of rope was delivered. In another instance, when the writer was appointed as an Assistant Engineer in charge of the erection of certain iron girder and suspension bridges in Sikkim (in the Himalayas), the materials of a suspension bridge were carried and taken over to the site by an agency outside his control, and when the steel wire cables were measured

they were found to be no less than 6ft. short of the length required, which of course meant a considerable delay in the erection of that particular bridge.

On one occasion the writer was asked to inspect a Municipal Waterworks in Burma, more especially in regard to the efficiency of the pumping machinery and boilers, and the question arose as to the duty of boiler inspectors, but he could not find in any Act relating to boiler inspectors that it was their duty to inspect the pumping engines as well as the boilers, though the Commissioner of the Division within whose jurisdiction the Municipality came considered that it was their duty. It would be a matter of satisfaction to those interested in the subject, to have the opinions of members as to whether boiler inspectors are ever required to inspect engines as well as boilers.

As regards standardisation, there is an increasing tendency in the Public Works Department in India to standardise tools, building materials, and iron and steel structures, the latter of which are designed to certain types, the more important structures being ordered from England, and the less important ones in India.

REPLY.

Mr. C. W. V. Biggs said that he thanked the meeting very much for the vote of thanks, and for the welcome which had been given to the paper. It was very gratifying to him that the paper had been the means of calling forth such interesting information as had been given that evening.

The President had raised the question about the statistics of breakdowns as being only half stated. The other half was classified as "Accidents" and "Improper use." He did not think that those were of much interest from an inspection point of view. The inspecting engineer could not provide against them.

With regard to cast iron, he had only given figures that seemed to him to be typical for the class of material supplied under the various headings. Several speakers had referred to the figures for pipe tests. The test pressure on pipes of course varied according to head, and these requirements would be set forth in the specification. If a pipe was intended to go under a road, although it only had to carry water at a small pressure, it had to be strong enough for a cart to pass over it. There was also the consideration of actual structural strength required for handling in transit.

With regard to machinery, in the majority of tests there did not seem to be any standard, and the unfortunate contractor did not know what was required of him. If he turned out a certain fixed type of machine he did not know how it would be tested, and he could not always allow for different tests. He did not deal with the contraction of area in tests because he thought that that was very difficult to measure.

With reference to interim inspections on castings, a great deal depended upon what was required by the consulting engineer, but it was rather a good thing to watch the pour, and also to see what was being put into the furnace in one or two cases in order to ascertain what class of work the manufacturer turned out.

As to checking the diameter of cylinders for horse-power, what he had said was suggested to him because in one case an engine would not develop the horse-power required, and it turned out afterwards that they had several sizes of cylinders, and too small a cylinder had been put in. If that had been found out earlier a good deal of money would have been saved.

With regard to insulators he had not personally seen the drying test, but he knew that a very large number of insulators had been accepted under the specification quoted.

He quite agreed with what had been said about testing boiler plates.

With regard to the hiding of wires it was very vexatious when there was a breakdown to have to cut the plaster and sometimes the brickwork.

One speaker had referred to instances of tests, apparently incomplete, which had been accepted by the inspector. The innocence of the inspector was at present delightful, and it seemed a pity to risk spoiling it by methods which, if repeated, he might be obliged to notice.

He had not any experience of deep-well pumps, a subject to which Mr. Shenton had referred. He should think that such a pump could be run in some way on the surface before being fixed, the chief difficulty being arranging for the artificial head.

Another speaker had referred to the extra cost caused by a large number of tests. That could be in a very great measure avoided if the tests could be run down to a certain series.

With regard to what Mr. Law had said, that was entirely a matter for a metallurgist, and he (Mr. Biggs) was not qualified to speak upon it.

The instance mentioned by Mr. Ackermann where the contractor was hung up on his own specification was a very interesting one.

Mr. Becks referred to an instance of an inspector who asked for tests which "could not possibly give him any information." The inspector was, however, there to gather information for his employers, and to see their specifications carried out, and not merely for educational purposes. He also quoted a case where elongation on 8in. was asked for, preferably to that on 2in. The elongation on 2in. was, of course, greater in proportion to the length for specimens of the same diameter. Doubtless, as Mr. Becks appeared to indicate, there were numerous omissions in the present paper, which might have been largely improved upon by extension, but this was equivalent to requiring another paper by a different writer. He agreed that this would be most welcome.

VISIT TO THE L.C.C. NORTHERN LOW-LEVEL SEWER.

On Tuesday, July 12th, 1910, a party of members of the Society and their friends, by kind permission of Mr. Maurice Fitzmaurice, C.M.G., M.Inst.C.E., Hon.F.S.E., inspected, under the guidance of Mr. J. E. Worth, District Engineer, the works now in progress in connection with the Northern Low-level Sewer No. 2.

With the great increase in the population of London, it became clear that Sir Joseph Bazalgette's scheme of intercepting sewers would require extension, therefore the London County Council in 1899 decided to enlarge the main drainage system. The works of extension, which have been completed or are now being carried out under the direction of Mr. Maurice Fitzmaurice, C.M.G., M.Inst.C.E., the Chief Engineer to the Council, include on the north side of the Thames two new outfall sewers, each 9ft. by 9ft., which have been added to the existing lines (three) of outfall sewer, and are now in use; a new Middle Level sewer, No. 2, from Willesden to Old Ford, some 9 miles in length, which is also being used, and a sewer known as the Northern Low-level No. 2, which extends from Hammersmith to Bow, a distance of $12\frac{1}{2}$ miles, parts of which are now under construction.

This latter sewer between Hammersmith and Pembroke Gardens, Kensington, is constructed in brickwork, and commencing with a 5ft. barrel, increases in size to 6ft. 6in. diameter at this latter point, from which it is constructed in iron segments as far as Eastfield Street, Stepney. The diameter of the sewer in this section varies from 6ft. 6in. to 8ft. 6in. From Eastfield Street to the pumping station at Abbey Mills the construction is in brick and iron, the diameter increasing from 8ft. 9in. to 10ft. 6in. at the latter place, where the sewage will be lifted about 42ft. into the outfall sewers, along which it will flow to the Barking Outfall Works. The depth of this sewer from the surface of the road varies from 20ft. to 70ft., and it lies chiefly in the blue London clay, although here and there water-bearing ballast is encountered. In these water-bearing sections it has been necessary to work with compressed air up to about 8 lb. on the square inch.

With respect to the construction of the portion of this sewer in iron, the segments are tapered on curves to the correct form,

all the faces are machined, and liquid grout is employed under pressure to form a solid backing. The ironwork is lined throughout with 3 to 1 concrete, and the invert from springing to springing with 4½ in. blue brick. The work is carried on night and day, and in twenty-four hours the tunnel advances by about eight rings, each ring amounting to 1 ft. 9 in. of distance.

At the Pont Street shaft, where the visit was made, the whole of the work is being carried out under compressed air with a shield.

**IMPERIAL
DEVELOP-
MENT.**

The present issue contains an article by Mr. C. R. Enock, F.R.G.S., M.S.E., in which is outlined a bold scheme of Imperial expansion which would, it is claimed, not only relieve the present unemployment difficulty in a general way, but especially provide professional work for engineers in developing the enormous natural resources of our Colonies.

Mr. Enock is not only an engineer, but also an author and a traveller. In addition to having published several books of travel, he has lectured before the Royal Geographical Society, the Royal Society of Arts, the Architectural Association, the British Association for the Advancement of Science, and other societies; and his experience of the conditions of life in new countries adds authority to the views expressed in the present paper.

We shall be glad to receive criticisms on Mr. Enock's proposals from our readers; any suitable communications on the subject will be published in a subsequent issue.

ENGINEERS AND EMPIRE DEVELOPMENT.

By C. REGINALD ENOCK, F.R.G.S.

[MEMBER.]

The subject of Imperial Colonial Development, as brought forward by the author in his address to the Royal Society of Arts,* and at the Emigration Conference at the Royal Colonial Institute, and in his travel books and articles in the Press, has aroused considerable interest, both in Great Britain and the Colonies. It is the object of this paper to shew that the development upon practical lines, and as it concerns the prosperity of Great Britain, of our Colonial Empire, is a work which might be more largely participated in by British Engineers, under a better system of organisation.

The author submits, that *the time has arrived for a systematic and scientific development of the great natural wealth of the Empire in the interests of its people.* No organised plan for this purpose has even been brought forward. All that has been done in the past has been upon so-called "natural" or haphazard lines, purely with private capital and for private ends. Whilst just recognition must be given to the great work done in opening up the waste places of the earth by this method, and the value to the nation of the private enterprise which has been so excellent a feature in the development of the Empire, nevertheless it is contended that it is time to supplement this system by enterprises, well planned and executed for the common good.

The great land resources of the Empire to-day, are either lying fallow, or are being acquired by private interests, and aliens. That is to say that homesteading and land purchase is going on rapidly in some of the Colonies, which is as it should be, but that no special privilege is accorded to Britons as against aliens, by the Colonial Governments; that foreigners from Europe and the United States are pouring in and acquiring the land, and that speculative individuals and syndicates have acquired huge areas. Thus, individuals are being unduly enriched by what belongs to the people as a whole, and without any forethought being taken for present and future generations. In a word, the great wealth

* February, 1910. A copy of the address was accepted by King Edward from the author.

of Colonial land is being squandered, and the defects of the land system of the Motherland, with all its attendant evils from which we are suffering to-day, are being reproduced and perpetuated.

It behoves British Engineers, whose work and livelihood is so largely connected with the land and its resources, and indeed all of Imperial mind, to ask why these conditions exist, how far they can be remedied, and what are the most practical methods for so doing. To develop those vast areas still lying fallow, and bring them into the stage of producing properties; and to conserve our national interests in those which are being unwisely disposed of, are the questions which must occupy the scientific and patriotic mind. It is claimed for the plan here brought forward that it will accomplish this, and it is hoped to arouse the professional and Imperial interest of Engineers in the great possibilities which the adoption of such a plan of Empire development would unfold. One of the minor points of such a development is that, if put on foot, the demand for the services of Engineers would probably soon exceed the supply.

The extent of the proposed work will be duly set forth. First, however, it is necessary to state the why and wherefore of the plan, and to endeavour to justify the claims made for it.

It is evident to all thoughtful observers that Great Britain, at the present time, appears to be at the parting of the ways of national supremacy. She must consolidate her Imperial life in conjunction with her colonial possessions, or run the risk of losing her predominance. Why is she in this position? The reason, whilst fundamentally simple, has scarcely been recognised yet, so greatly are men's minds obsessed by questions of politics and tariffs. It is necessary to remind ourselves of certain geographical and economic facts of the first importance to Britain's welfare, and indeed to the safe existence of her people. We have now 45 million inhabitants approximately, upon what, territorially, is a relatively small island, incapable, as regards food products and raw material, of maintaining them. With the exception of a mere fraction, the whole of this great population is living upon commerce and manufacture, and suffers continually by reason of trade fluctuations. This must be looked upon as a condition fraught with danger. We cannot expect our trade predominance to endure always; other nations are rapidly supplying their own wants, which will result in a declining market for our manufactured articles. More, it is a sufficiently evident fact that trade does not and cannot support all our people, and as our land resources in Britain are insufficient for so large a population it follows that we have to maintain a great army of poor and unemployed, which statistics shew cost the country something like thirty millions sterling per annum in poor law relief, charities, etc.

But whether the cause of the insufficiency, which is the most marked social feature at present, is mainly due to our system of commercialism or not, the fact is evident that we are suffering severely. Our statisticians inform us that seven-tenths of our population come permanently under the heading of "poor." A recent Prime Minister,* in a speech, reiterated the fact that there are twelve millions of people in England on the verge of starvation; whilst the serious condition of unemployment, as indicated by the Trade Union returns, the Labour Exchanges, and the columns of our daily papers, shews a state of things which can only be described as appalling, especially for a civilised nation such as Britain, who boasts that her Empire covers a quarter of the land area of the globe! We are assailed at every turn by numerous charitable societies with demands for this or that charity; which, with the fact that the London County Council are obliged to give to their school children something like nine million free meals annually, is a painful indication of the state of the cupboard of our poorest classes, such as might give to us who dwell in comfort, food for thought, and bid us strain every nerve to apply some Imperial remedy. "Is there any remedy?" will be the first question. It is the purpose of this paper, and the movement inaugurated by its author, to demonstrate that there is; and to shew how it may be put into practice.

Lest it were possible, however, that public apathy should proclaim that the subject is one which can take care of itself; which indeed has been the traditional attitude of our statesmen so far, let us see what the condition of widespread poverty means. It means not only the curtailing of bodily nourishment, and consequent physical degeneration of the people, but the denial to the citizen of any opportunity for his civic and mental progress. We shall not be able to continue to breed an Imperial race in our overcrowded slums, nor produce an improving civilization when more than half our people are below the poverty line. Moreover, the grey horizon of our workers who own neither land nor house, and who are dependent so largely for their daily bread, upon the fluctuations of trade, can never lift under present conditions, nor lead on to national advancement. On the contrary, the experience of to-day shews that it leads rather to Socialism, and Socialism is not connected in our minds with civilization. It is not a creed ever likely to appeal to Engineers, and, moreover, it is antagonistic to Imperialism, which it is here contended is the safeguard of British predominance. Thus we see that the condition of poverty and insufficiency which is so ripe in Britain to-day is positively a national menace. On the one hand it might lead to revolution, on the other it cannot be expected that a great crowd of 25 million of underfed or landless

* Sir Henry Campbell-Bannerman.

citizens would have either the inclination or the stamina to protect themselves against a foreign foe. "We have no homes, let those who own the land defend it!" was the sinister but significant cry which has already been uttered.*

It is the duty of all therefore, as a measure of common humanity, common sense and prudence, to exert ourselves to the effacing of these conditions. We can no longer leave it to the traditional custodians of the Empire; they have ever been, and possibly ever will be, too apathetic to attempt more than merely parochial remedies. On the other hand we are all custodians of the Empire who have wealth or influence, or voice or pen to use generously or scientifically; and as engineers we could make our voice heard with no uncertain demand, and so influence those in whose possession lie the means and the power. If we are to raise and perpetuate a race of improving beings, poverty and insufficiency must be banished. The plan here to be advanced, it is claimed, will perform this. If we are to continue to be citizens or subjects of a strong and growing Empire, we must all have a tangible share in or hold on that Empire. At present the Empire is little more than a name to the bulk of British people. Many of them might become sarcastic if you told them that the "sun never sets" upon our Empire, as our poets tell us, and inform you that the waving of the Union Jack will not fill an empty stomach or find them a job. It might sound unpatriotic, but it would be hard fact. As engineers we have to deal with facts, rather than sentiment, but we shall here ask ourselves if patriotic sentiment and common-sense fact are not capable—as regards the British Empire—of being interwoven.

We may first lay it down as an axiom that the Empire is capable of supporting all its people. Let us therefore wave the Union Jack a moment, like a magician's wand, or use it like an enchanted carpet. What does it do? It transports us from these overwrought Islands of Britain—overwrought, as we have seen, for the bulk of our people—to the enormous Colonial possessions, which we won by our forefathers' energy and conquest. Here is the answer to our cry of insufficiency. Here, in Canada, Australia, Africa and our other possessions, we own the greatest wealth of land that any single nation in the history of the world has ever possessed. Our territories produce every animal, vegetable and mineral product, from the Equator to the Arctic circle. They are in great part inhabited by a mere handful of people. Canada is 70 times the size of Great Britain, with about seven million people; Australia is only slightly less, with 3 million square miles and 4 million inhabitants; Africa, South, Central, East and West, has huge areas with a mere sprinkling of white men; and there are other vast regions under our flag,

* At a meeting for the purpose of discussing national armaments.

capable of maintaining in plenty the surplus millions of our people.

Now any study of the present conditions of settlement and immigration in the Colonies shews that, whether from a scientific point of view or from the standpoint of ordinary business methods, these conditions are inadequate, or worse than inadequate, as far as benefiting our people as a whole is concerned. The system, if such it may be called, is that of a sort of survival of the fittest, under which those who have sufficient means or land-working capacity go out and take up or purchase land. This is good as far as it goes, but as a means of Empire development it will not benefit the great class in Britain of working people and the poor, which, as we have seen, embraces half our population. The population which stays perforce at home and forms the heart of the Empire is equally entitled to a share in the Empire. Further, the present Colonial land laws permit the acquisition of free land by people not of the British race. This again is not to be decried altogether, because population is the chief requirement of those new British States, and also, some admixture of European and American blood generally must be advantageous in the making of new nations. But it may go too far. Already the foreign immigrants into Canada are two to one of the British. American farmers have acquired, and are acquiring in greater force every day, enormous areas of the best wheat lands in Canada. From the Colonial point of view it is an excellent thing that new nations are rapidly being created in this way; but from the British Imperial standpoint we feel called upon to say that our birthright and heritage is being given away. The author's representations upon this point, in his previous lectures and articles, and the discussions at the Royal Society of Arts and Royal Colonial Institute, have educed expressions of opinion from the Dominion and Commonwealth representatives in London, generally to the effect that, whilst they welcome and prefer British settlers, they cannot wait whilst we at home "wake up" to the advantages of Colonial lands. Further, their immigration policy is to a certain extent one of restriction. Emigrants from Britain are carefully selected, and if they do not come up to the standard set by the Colonial authorities they are rejected; some thousands indeed have been deported.* The Colonial policy is to encourage by all means possible the immigration of farmer capitalists, farm hands, and domestic servants, but to discourage anyone of the ordinary profession or trades, complaining that they are already overstocked. They are extremely opposed to the immigration of our unemployed, which they dub "undesirables," and this is a very serious matter for us.

Now whilst, in giving self-government to these energetic

* From 1903 to 1909, 2,300 British immigrants were sent back by the Canadian authorities.

and progressive communities of Canada and Australia, Britain has enabled them to work out their own methods, and would scarcely be likely to interfere therewith, we, at home, are well within our Imperial sphere in asking by what right they are permitting, first, the acquisition of land in such rapid measure by aliens, and second, by what right they exclude any of our citizens. The author of this paper has brought forward two claims, which have been much discussed; that, until every British citizen is provided for, both as to his present and future wants, it is robbing him of his birthright to allow the land to be acquired by foreigners; and that the Colonies have no more right to exclude British immigrants of whatever status, than London has the right to exclude people from Manchester, Edinburgh, Toronto or Melbourne. Both these matters must surely fall within the purview of Imperial statesmen soon.*

It is not the purpose of this paper, however, to discuss the matter, nor would it be a profitable one for engineers to deal with. Moreover, the plan which is to be discussed here would serve to provide a remedy for the situation. This plan has been put forward by the author under what he has ventured to term a "New Imperial Doctrine," expressed as follows: "Let the ratepayers of each City and Municipal District in Great Britain acquire an area of fertile land in the Colonies, hold it in perpetuity as a heritage for its people, and develop it for their needs, creating new centres of industry and fresh sources of revenue upon it. This "doctrine" has been very widely discussed, and although, as might be expected in a new principle, it has called forth some criticism, yet it has generally been received as a sound proposal, especially in the more responsible Imperial quarters. The author maintains that this plan is pregnant with possibilities for engineers, as will be shewn.

A bold principle of this nature, of course, invites the fullest discussion, and must be stated in detail, which will now be done. The method of procedure for the creation of the new property should be as follows: The first step would be the calling of meetings of the influential ratepayers and residents of each and every city in Britain, and the appointing of a Board of Commissioners for each, to deal with the matter. What connection these organisations would have with the Local Corporations or Councils would be a matter for determination. In some cases perhaps the Civic Authorities might take the leading step themselves, but it is doubtful if they would. The organisation having been established, some small preliminary funds are required, and these might be furnished among the wealthy ratepayers, upon terms of subsequent re-imbursement; or as a

* The author brought this matter forward again at the Emigration Conference at the Royal Colonial Institute, May 31st.

measure of generous Imperialism. The next step would be to approach the various Colonial Governments, Canada, Australia, South Africa, or the Crown Colonies, but especially the self-governing Dominions and Commonwealths, in order to obtain grants of territory of a desirable nature under the most advantageous terms. The property so to be acquired would be vested in trustees, to be held as the property, in perpetuity, of the particular community—London, Manchester, Edinburgh, etc.—which called it into being ; and every ratepayer would, ipso facto, become a “shareholder” in it.*

A field of operations having been decided upon in one of the Colonies, the work of the Engineer now becomes paramount. The Commissioners would appoint engineers with knowledge of land development work to go out and report upon the various available territories, when selection would be made. The area of territory acquired would be as large as was required and would be selected for its natural resources of agricultural land, minerals and mining possibilities, forests, and their allied industries, rivers and fishing grounds, water-power, etc., combining as many natural advantages as possible. This being satisfactorily accomplished, the home community would find themselves in possession of great valuable landed properties, which they had acquired *simply by organising themselves and reaching out therefor*. The value of the properties, apart from what would immediately be done upon them, *would at once increase from the mere fact of their being owned*. The value of Colonial land is rising in an unprecedented manner, and new towns are arising rapidly, especially in Canada.

We now come to the matter of working capital ; secondary only in importance to the land. Two methods, either of which might be adopted, or a combination of both, are here put forward. The first is that of a small levy on the rates. When we reflect upon the heavy taxation to which we are already subjected, we might hesitate to suggest such a course, but this will be followed by the reflection that the enterprise, if successfully carried out, will be *positively an investment rather than a dole*, such as our Poor Rates must be considered to be at present. The 30 millions, more or less, annually which we pay for poor relief might, under this plan, be wiped out. The second method would assume that the enterprise, being carried out on strictly business lines, under efficient managers and engineers, with the sound basis of a valuable property under the British flag, containing possibilities for all remunerative industries, should appeal to capitalists in a double sense—that of earning dividends on the money invested,

* The Premier of Newfoundland accepts the proposal for his Government in a letter to the author, and offers a tract of territory for the purpose. The Premier of Western Australia also is desirous of considering it.

and of tending to relieve the increasing taxation ; whilst at the same time benefiting and extending the wealth of the community of which they are part. Capital could then be invited under ordinary "company" methods, which should provide for the return of principal and interest, if desired, from revenue earned. Whichever method were adopted, however, it is conceivable that public spirit being aroused, together with the awakening to the enormous and growing benefits to be derived pecuniarily from the exploitation of Colonial lands, no difficulty would be encountered by our large cities in raising funds.

Having now the property and the working capital, our road is open to the matters of administration, settlement, labour, establishment of industries, and general development. In all these matters the engineer must play the leading part. He must direct operations, for the manager who is not at the same time an engineer cannot adequately fulfil the requirements of development work of this nature. Under the manager or administrator there would be a numerous corps of engineers—civil, mining, mechanical—in the busy centres which would be inaugurated in the numerous areas which would be simultaneously under development. The author submits that the possibilities are alluring in the extreme to British engineers. Hitherto full employment for their powers is often lacking. At home our roads, railways, docks, and buildings are largely built ; in the new territories all would have to be performed, and everything that has been done in past centuries in England by engineers to make the country great could be duplicated, and more than duplicated, in these great new worlds of enterprise which would be called into being "to redress the balance of the old." Roads and light railways would be laid out, agricultural land prepared, mines and quarries opened, forests explored (with special attention to planting in those areas where forests did not exist), industries outlined, factories built, town sites prepared, and so forth.

All this leads immediately to the matter of settlement and labour. Simultaneously with the preliminaries of acquisition of the territory the classification and organisation of the people at home would be carried out, and every person who desired to emigrate or take part in any way in the Imperial movement would be registered. From these the best labour would be at once drafted out, arrangements being made for a chartered vessel to convey them, in order that the present cost of transport might be reduced to the lowest possible point. These would be immediately employed, at current wages at first, upon the land, in the works outlined above, and in getting in the greatest possible area of crops, with the object of obtaining revenue at the earliest possible time. The payment of current wages would be preliminary to an additional co-operative share, such as will be outlined later.

The classification of the people of the home community would give, more or less, the following grades:—

(1) People of the upper class who desired to take an active interest in the work, either by the investment of money in it or by going out or by establishing their sons and daughters upon the property.

(2) Upper class people without means, but desirous of going out and cultivating land or performing other work, both men and women, probably of all professions and businesses.

(3) Farmers with capital desirous of putting their money into the land.

(4) Farm labourers without capital.

(5) Able-bodied labourers without farm experience or money.

(6) Small shopkeepers, clerks, shop assistants, and others accustomed only to indoor work.

(7) The "unemployed," who would naturally become split up into some of the above divisions.

(8) The "unemployable," or that percentage of the unemployed found to be wastrels who will not work, or who are "undesirables" in other senses.

As shown, all the able-bodied labour would have an immediate field of work, as would also be the case for those with money who desired to take up and work a portion of the land on their own account. The others would be drafted out as the new community developed. The call for their services would be rapid, whether men or women, for the work would not be confined to mere land cultivation, but to the establishing of all industries which the resources of the particular regions might afford. New villages would be established wherever desirable, and small manufacturing and shopkeeping set on foot; all to be controlled by the co-operative principle which would underlie the organisation. In brief, all the occupations of the people at home would be set going, except that the defects of over-competition, overcrowding, and overlapping would be eliminated. The whole purpose of the enterprise would be to promote prosperity without reproducing the evil conditions of the old world. Social interest and local pride would be nourished and maintained with the home centre, and a constant interchange of visitors and literature effected as time went on.

The unemployed class might in some cases call for special treatment, as contrasted with those who were emigrants from positions at home. The most serious condition about unemployment is found in the deterioration which takes place even in the able-bodied and young after chronic unemployment. To remedy this, training farms would be established upon the new properties,

where those who had deteriorated would enjoy a period of training and feeding, and it would undoubtedly be found that such "patients" would more than cover their cost by the amount of work performed. Undesirables and incorrigibles would have to undergo some special treatment of a semi-penal nature, and it would be useless to send people of that character out at first. Their term of probation would be best dealt with at home; but each city must care for its own, and defray the cost from the revenue of the new property.

The advantages arising out of this plan of Imperial Colonial Development would accrue both to Britain, the Colonies, and the Empire at large. The municipalities of England, Scotland, Wales, and Ireland would have acquired a broad field for their operations. Their emigrants, instead of being, as now, pitchforked out into strange conditions, would go to prepared areas rendered attractive by ties of local association. One of the greatest bars to emigration has ever been the semi-penal or banishment idea, which it has always conveyed. This would be removed. It would no longer be the emigration of outcasts, but the migration of Imperial "shareholders" from one part of their property to another. Also, the great question among upper class people at home of "What shall we do with our sons?" and "What shall we do with our daughters?" would find a solution here. Moreover, an attractive field for the investment both of private and municipal funds would be opened. Cities such as London, Manchester, Birmingham, Edinburgh, and all others would have acquired splendid new properties and what were practically extensions of themselves overseas, giving them a means of subsistence and source of profitable employment for all their people, who would be drawing new sources of life therefrom. Municipal rates and taxes would become lowered; mean streets and slums would become uninhabited, over-competition in industry would be reduced, and the sweated worker would have departed never to return. As to unemployment, the word would fall into disuse. Poverty should tend to become an unknown quantity, and with its disappearance would go a long category of vices and crimes which are at present mainly its progeny. This may seem a big claim to make, but it is a logical one.

The advantages to the Colonies would be in the opening up of great territories and their settlement by people of British stock; the influx of capital and labour, and in addition the elimination of the danger of unemployment in their own centres. Under present conditions our Colonial kinsmen are simply reproducing in their own clean new areas the evil conditions of the Old World from which we suffer in Britain. Our Imperial territory is being squandered and made over to individuals, aliens, and syndicates, and this is only a replica of Old-World methods, which forbids

the use of the land for the good of the community at large. Moreover, the present methods of immigration take to the Colonies mainly people of the working class, which does not tend to raise the intellectual or social status of Australia or Canada, whereas the ordered settlement which this plan would bring about would induce settlement of the refined and moneyed classes of Britain in addition. The whole Empire would be bound together by the bonds of a legitimate self-interest, as this work of Imperial penetration and self-help became general.

It is scarcely* necessary to discuss in this paper the question of where the territories exist which would be acquired, but a few words must be devoted thereto. Canada, with its area of $3\frac{1}{2}$ million square miles, may be divided for the purpose of this paper into three classes of land: First, that already owned and developed; second, that awaiting development and ownership; third, that requiring special conditions of development, including those portions which are non-cultivable. The first of these, the land already developed, is a small part of the available area. Similar conditions exist in Australia, with its 3 million square miles and 4 million people, the cultivated land scarcely forming more than a fringe around the edge of this great island continent. In Africa, again, we have the same conditions of a handful of white population and enormous undeveloped territories.

To enumerate the food products and raw material of these splendid portions of the Empire would be to give a list of almost everything known to the commercial world. Canada yields wheat and other cereals, cattle, dairy products, timber, fruits, fish, gold, silver, copper, petroleum, iron, coal, and other minerals, most of these products being found or cultivated in such importance now as fairly to astonish the commercial world. Australia gives all the above, and in addition yields semi-tropical products, such as sugar, etc. Africa holds, with small exceptions, all these things also.

Whilst we in Britain, in a general sense, have little knowledge of these countless riches lying to our hands, our Colonial kinsmen are far more awake to their value. Here are some of the standing official announcements made by the various Colonial Governments in the Press and in their alluring pamphlets, and these, whilst they are sometimes too highly coloured, have such a margin of truth as can never be disputed:—

“The twentieth century is Canada’s. Canada offers 160 acres of land free to every male. Millions of acres still available. A home in the land of sunshine and contented people with the best land on earth, low taxes, good markets, free schools. Land rich in timber, minerals, and agricultural possibilities. Millions of acres of first-class land awaiting the settler in a good climate. Twenty-five million acres in Manitoba to be homesteaded. Win-

nipeg, with 40,000 people in 1901, now has 400,000. British Columbia is the orchard of the Empire. Alberta has 250,000 square miles, rich in agriculture, minerals, fisheries, timber. Why pay rent when you can buy an improved farm in Canada for the equivalent of two years' rent in Britain?" That is how the Canadians describe the land. What does Australia say? "The Commonwealth, a land of sunshine and prosperity for the settler, wants emigrants and extends a hearty welcome to those of the white races who will farm her lands. A new home for the British people under the British flag. Come to Australia, where every man who likes to work can have his own home on his own land, where millionaires are few but people prosperous. Victoria, the Garden State, nearly as large as Great Britain, good soil, splendid climate, abundant rainfall, light taxation, etc. Western Australia, the land for settlers. Fifty million acres available for selection, with regular and ample rainfall. The most liberal land laws in the world; free grants of 160 acres, etc."

It almost takes one's breath away to read of these riches flung into our faces, and we may well ask ourselves how it is that we make no organised use of them to benefit Britain as a whole. The pages of those London journals* devoted to Colonial affairs read like a fairy tale. Thousands of miles of railway are being strung out over entire continents, new towns are rising every day, hundreds of thousands of people are pouring in of all races, to share in the great wealth which is being wrought from the virgin soil. Free land, free farms, plenty for all. In a few years' time, when all these bounties have been given away, it will read like a dream of the Arabian nights!

What part are we as engineers to play in this twentieth century development? Our work may be, first, in initiative and organisation, second, in development in the new industrial fields we hope to create. Every engineer who has time and energy to spare may take upon himself to influence the particular community in Britain with which he is connected to form organisations such as that outlined in this paper. In his native town or the place of his employment he could call meetings and direct the attention of the Press and the local authorities to the subject, offering his services as far as they are available to the carrying out of the work. When the plan takes hold of the public mind and is put into execution, the services of every engineer in the land would be requisitioned and he might be expected to reap a lasting benefit from its operations, both professionally and as an Imperialist; whilst the community should have cause to congratulate itself upon the scientific development of the Imperial property.

* Such as the "Standard of Empire," "Financial News," etc.

CORRESPONDENCE

ON

“ENGINEERS AND EMPIRE DEVELOPMENT.”

Mr. G. A. Becks writes :—

Mr. Enock's able enunciation of a scheme which appears to contain much more than a nucleus has aroused my warmest appreciation, and those dormant desires, which I believe exist in the inner mind of every one who has been engaged, as I have, upon pioneer work in the Colonies, to return and devote their lives to the advancement of the Empire.

This is not the place to enter into details of past experience, but the indescribable feelings of happiness which I have had when doing pioneer work in the knowledge that those who followed me would benefit therefrom, passes understanding, and I welcome Mr. Enock's scheme all the more because I see in it the means, if once the apathy of the public can be overcome, of doing more pioneer work in the future. For the furtherance of this Imperial expansion and development I most cordially offer my services and co-operation, and in the meantime I shall press the scheme on every available occasion.

Mr. Enock does not say anything about the size of the tract of land which should be acquired by the different communities, nor does he place any tentative limit to the number of persons to be sent out in the first instance by such communities. What would be a fair proportion of the inhabitants in each locality who could reasonably be expected to emigrate? I should think if one per cent. would be willing to go, it would be as many as could be expected, not because a larger number would not materially benefit, but because home ties would be too strong.

On the above basis, and further on the basis of 10 acres per man, on a total population of 45,000,000 we should require 4,500,000 acres, or a tract of land measuring roughly 84 miles square. What a speck on the total area of Canada alone! Of course it may be said that 10 acres per man is not sufficient, but it must be remembered that it would be much too great for the majority of those who emigrated. What would such a tract of land cost? In some parts of the great West I have no doubt that, properly approached, the Canadian Government would give it away in return for a certain interest and subject to certain small restrictions.

The acquisition of the land, however, to my mind is not so difficult a matter as the acquiring of capital to develop it. Mr. Enock suggests that Municipalities might levy a tax for the project, but would the taxpayers submit? It would be a long

time before they saw a reduction of their rates due to the profit from their outlay, and unless an Act of Parliament was passed authorising the levying of the tax, I rather think there would be trouble in the land.

The scheme having been formulated by an engineer, should be taken up by engineers, so that the honour of the achievement may belong to us as a body.

Mr. Enock submits in his opening remarks that the time has arrived to take action, and as he undoubtedly has given more thought to it than I, it is with pleasure that I put myself at his disposal and wait for further orders. It may be, however, that Mr. Enock, having given the scheme to the nation, is content to rest on his laurels, and leave the working out to others, but he must not be allowed to do this. Having made the proposals we must look to him for the second step. It is certainly not one man's work to conduct this great scheme throughout the length and breadth of the land ; we must have workers, and I hope I may head the list.

That initial expense must be incurred is inevitable, and I suggest that, as the scheme is one greatly in the interest of engineers, the engineering Societies of the Kingdom might each contribute a sum of money from their funds to enable the matter to be carried out thoroughly and systematically.

Mr. Enock's proposals are of such vast importance that they must be taken up at once, without a moment's delay, for if any apathy be shown, it will be too late ; private interests and aliens will be before us, as, I regret to say, they have been many times. The scheme now published to the world must be acted upon forthwith or the very advice and warning given us for our protection and guidance will be taken up by others, to our undoing.

Mr. P. G. Scott writes as follows :—

The problem of the undeveloped resources and the unutilised powers of nature in the British Empire and the means that could or ought to be adopted for utilising such resources has often presented itself to me. Mr. Enock's article puts forward a scheme which would bring about the closer union of the various parts of the Empire and afford work for a large number of unemployed, as well as for those who are not profitably employed. It will, however, depend on those who have the means or the influence, and who consider the suggestions feasible, to give them effect. As a Fellow of the Royal Colonial Institute, I have had opportunities of reading and hearing papers and discussions dealing with Empire Development by leading men, and have also read an account of the Emigration Conference recently held at the Royal Colonial Institute. The keynote of these papers and discussions has nearly always been the need for co-operation and a better understanding of the people, and a knowledge of the resources

of the constituent parts of the Empire. I will only deal with Empire development as affecting Engineers, though every aspect of the problem is very closely related.

Absque labore nihil.—Every engineer knows that his study, observation and investigation leading to the formulation of engineering schemes could take no material shape without the aid of manual labour, skilled and unskilled. But the crux of the matter is how to utilise the labour when it is available. Certain schemes have been put forward by Mr. Enock, which I do not propose to investigate; but whatever the schemes are, their products, whether agricultural, mineral, or manufactured, must have markets, and this bears directly on the commercial relations of the parts of the Empire to one another and to foreign countries. This problem is so vast that it must be left to those who have made it their special study. The question under consideration really resolves itself into two parts. On the one hand there is man-power lying idle or going to foreign countries, and on the other hand there are the latent resources of the Empire awaiting development. What is the best way of combining the two for the benefit of all concerned, and ultimately for the closer union of the Empire? I will quote from an article contributed by Mr. Archibald R. Colquhoun to *United Empire*, entitled "Thoughts on the Emigration Conference," to show what is the present state of affairs. Mr. Colquhoun says—"Meanwhile a leakage of man-power is going on from the British Empire, which it is equally to the interests of every part of that Empire to prevent. Between 1876 and 1908, $2\frac{1}{2}$ millions went from the United Kingdom to the United States (this is the number of those who *settled*), whereas (in round numbers) Canada retained 805,000, Australia and New Zealand 500,000, and South Africa 127,000. According to the opening speech of the Chairman of the Conference no fewer than 110,000 went to the United States in 1909, as against 135,000 to overseas Dominions."—From the above it will be noted that the British Empire was weakened during the period mentioned by the emigration of $2\frac{1}{2}$ millions of people who might have helped to open up some of its undeveloped parts, which would have meant incidentally more work for engineers where labour had to be employed in engineering works.

I shall now touch on some of the disabilities from which many engineers suffer, and afterwards advance some suggestions which may tend to ameliorate them.—(1) There are periods of rush of work, and this often means the employment of a number of unqualified men because they happen to be on the spot; but when the works are completed a number of men, among them well-qualified engineers, are sent adrift.—(2) There are vast portions of the Empire where the natural resources are unutilised

—(3) The field of work for engineers is restricted.—(4) There is not enough co-operation among engineers themselves, nor between them and their clients. To overcome these defects a well-organised Intelligence Department should be instituted.

It would be useful to have an engineering geography with explanatory maps, showing all classes of engineering works constructed and under construction, the powers of nature available but unutilised, the resources of the countries, the parts undeveloped, the population, physical features, climatic conditions, rates of wages, class and extent of labour available, and similarly for agricultural, mineral and manufactured information. A good deal of such information is already available in ordinary geographies, but it is disjointed and incomplete as far as engineering matters are concerned, necessitating laborious search for information required. As regards the employment of unqualified men and the protection of qualified engineers, I would propose that a Directory of Engineers should be compiled giving the principal work and qualifications of each engineer, and that the profession be made a closed one.

When larger works are completed or industries set going by engineers, they are often left to the management of others. This is to a great extent the fault of engineers themselves, who are in a large measure content to be employed by various bodies in a subordinate capacity. There are, however, notable exceptions—where the initiation, completion and subsequent management of irrigation schemes, some railways, and a few manufacturing concerns are in the hands of engineers.

I would propose as a measure of relief that the Councils of British Engineering Societies should co-operate to establish an engineering Intelligence Bureau. Honorary Corresponding Secretaries might be appointed by the respective Societies from among the members residing in outlying parts of the Empire. There should be interchange of transactions between the Societies and useful information should be compiled for the engineering geography. I would also propose that qualified members residing in distant parts of the British Empire should be elected to the Councils of the Societies, to represent their particular territory. Copies of the Engineering Directory already referred to should be kept by each Society and supplied to the public libraries. The measures suggested above are supplementary to the useful work which is already being done by the Engineering Societies. I trust that the suggestions outlined may tend to bring the engineer and his work in closer touch with the general public and to strengthen the ties of Empire.

REINFORCED-CONCRETE RETAINING WALLS.

By E. R. MATTHEWS, A.M.Inst. C.E., F.R.S.E.

[MEMBER.]

It is the intention of the Author in this paper to state first the advantages of using reinforced concrete in the construction of retaining walls ; then to describe in detail certain reinforced-concrete retaining walls recently constructed by him at Bridlington, giving the cost of same ; to give in full his calculations regarding the strength of some of these walls ; to discuss the best method of finishing exposed surfaces in concrete, the best way of making concrete waterproof, and the introduction of expansion joints ; and to conclude by describing briefly a few typical examples of reinforced concrete retaining walls constructed in the United States.

(1.) THE ADVANTAGES OF USING REINFORCED CONCRETE IN THE CONSTRUCTION OF RETAINING WALLS.

There are two main advantages, and these are—

(a) *Economy in cost.*—The Author's experience has taught him that a reinforced-concrete retaining wall can be built at 25 per cent. less cost than a similar plain concrete wall, and 28 to 30 per cent. less than a brick wall, or a concrete wall with a brick face, and his experience seems to coincide with that of American engineers. Fig. 1, for example, illustrates a reinforced-concrete retaining wall with counterforts, built by the Canadian Pacific Railway at Montreal. This wall was designed by Mr. J. G. Sullivan, Assistant to the Chief Engineer, and is a typical section of the walls built by that Railroad Company. Mr. Sullivan says concerning it :—

“ With regard to cost, we have found that for walls up to 35ft. high from bottom of foundation slab, the reinforced concrete is about 25 per cent. cheaper than monolithic concrete.”

This wall is 3,400ft. in length, and 21 to 25ft. in height.

Figs. 2 and 3 represent very large hollow retaining walls constructed in reinforced concrete by the Atlanta, Birmingham and Atlantic Railroad. These were designed by Mr. Alex. Bonnyman, General Manager and Chief Engineer, who writes regarding them as follows :—

“ By the contract prices for plain concrete and reinforced concrete, we figure that there is a saving in the reinforced walls of about 25 per cent.”

The wall shown in Fig. 3 is 61ft. in height.

The quantity of material necessary to be used in a concrete wall (monolithic) compared with a reinforced-concrete wall will be seen by comparing Figs. 1, 8 and 9 with Fig. 4; these sections represent walls of similar heights, erected a short time ago on some of the American railroads, and are typical sections.

(b) The second recommendation is that *much less space is occupied by a reinforced-concrete wall*, and this is sometimes a great advantage. Fig. 5, for example, shows a reinforced-concrete wall designed by the Author, which fulfils a purpose such as a wall built of any other material would fail to do. It was necessary to design a wall which would occupy a minimum of space above the level of the adjoining footpath, and yet would be of sufficient strength to act as a retaining wall, and also to carry the reinforced-concrete roof, upon which a crowd of people might gather. Reinforced concrete proved an admirable material for this purpose. The Author describes this wall in detail later.

(c) A reinforced-concrete wall is also much lighter than a retaining wall constructed of stone, brick, or monolithic concrete.

(2.) REINFORCED-CONCRETE RETAINING WALLS AT BRIDLINGTON.—The Author will now describe some reinforced-concrete retaining walls and a flat roof which he has recently constructed at Bridlington in connection with a partially underground lavatory.

Concrete.—The concrete was in the proportions of 1:2:3, namely, one part Portland cement capable of passing the standard tests, two parts clean sharp sand, and three parts sea gravel, capable of passing through a 1in. ring.

Steel.—This had to be of British manufacture, and capable of withstanding a tensile stress of 60,000lbs. per sq. in. No reinforcement was allowed to come nearer than $1\frac{1}{2}$ in. to the face of the concrete.

Shuttering.—This was substantial and formed chiefly out of 7in. $\times$ 3in. deals.

Cement grouting of steel bars.—All reinforcement was dipped in cement grout at least four hours before use.

Dimensions of Retaining Walls—

Length	47ft.
Height above bottom of foundations	12ft. 6in.
Width of foundations	4ft.
Thickness of foundations	7in.
Thickness of wall	5in.
Width of counterforts	2ft. 9in.
Thickness of counterforts	7in.

Dimensions of reinforced concrete beams—10in. $\times$ 8in. (longest clear span 13ft. 6in.).

Thickness of reinforced concrete slabs— 5in.

Roof covering— $1\frac{1}{2}$ in. of Limmer Asphalte, put on in two layers.

Nature and size of Reinforcement—

In Foundations.—The transverse bars were $\frac{5}{8}$ in. (round) set at 6 in. centres and connected by clips. The longitudinal reinforcement consisted of two $\frac{5}{8}$ in. shear bars locked to transverse bars with clips.

In Wall and Counterforts—

The reinforcement consisted of $\frac{1}{2}$ in. round bars fixed longitudinally at 6 in. centres, with steel clips, 20 in. centres, and vertical shear bars $\frac{7}{8}$ in. placed at 3 ft. centres with clips.

In Beams—

These were reinforced with $\frac{7}{8}$ in. bars cranked in an upward direction towards supports with transverse and vertical clips as shear members.

In Slabs—

The reinforcement of these was as follows:— $\frac{1}{2}$ in. bars fixed at 6 in. centres with clips, with diagonal shear bars at 3 ft. 6 in. centres, locked to $\frac{1}{2}$ in. bars with clips.

Cost of reinforced-concrete work and Limmer asphaltting £293 2s. 5d.; estimated cost of monolithic concrete wall and asphaltting £368; saving 20 per cent. These works are illustrated in Fig. 6.

The forms were removed after they had been up four weeks. The roof is in every way watertight, and the walls present a smooth and uniform face. The combined live and dead load allowed for was 2 cwt. per sq. ft. The period for which the L.G.B. have granted the loan is 27 years.

The other retaining walls of reinforced concrete which the Author has now in hand may be briefly described as follows:

R.C. Retaining Walls and Roof forming shelter on Sea Front at Bridlington, north of Harbour.—These are illustrated in Fig. 7:—

Retaining Walls—Dimensions—

Length	150ft.
Height above bottom of foundations	14ft 6in.
Thickness	9in. to 5in.
Width of foundations	6ft. 9in.
Thickness (strengthened by an 18in. by 12in. R.C. beam)	8in.
Width of counterforts	4ft.
Distance apart	14ft. $3\frac{1}{2}$ in. (centres).
Thickness	11 in.
Width of piers	11 in.
Distance apart	14ft. $3\frac{1}{2}$ in. (centres).

Reinforcement—

In Foundations	$\frac{5}{8}$ in. and $\frac{3}{4}$ in. bars.
In Retaining Walls	$\frac{3}{4}$ in. and $\frac{7}{8}$ in. bars
In Counterforts	$\frac{7}{8}$ in. and 1in. vertical bars, and $\frac{3}{4}$ in. transverse bars.

All bars connected by steel clips.

In Piers	$\frac{1}{2}$ in. and $\frac{3}{4}$ in. bars.
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Beams—

Dimensions	14in. $\times$ 11in., 14in. $\times$ 8in., 14in. $\times$ 7in., and 10in. $\times$ 7in.
Reinforcement	$\frac{3}{4}$ in. bars.

Roof Slab—

Thickness	5in.
Reinforcement	$\frac{1}{2}$ in. and $\frac{5}{8}$ in. bars

The roof covering was Limmer Asphalte $1\frac{1}{2}$ in. in thickness. The concrete was 1 : 2 : 3 as before.

Cost.—The tender for this work was £635 10s. 4d., the Author's estimate for a monolithic concrete wall, with roof of steel joists and concrete, with Limmer Asphalte covering, was £800.

R.C. Retaining Walls and Roof forming shelter and part of Public Lavatories on south side of Harbour at Bridlington (see Fig. 5) :—

Retaining Walls—Dimensions—

Length	140ft.
Height above bottom of foundations	13ft.
Thickness	9in. to 5in.
Width of Foundations	5ft. 10in.
Thickness (strengthened by a R.C. Beam, 1ft. 6in. $\times$ 10in.)	10in.
Width of counterforts (below ground)	3ft. 3in.
" " " (above ground)	$4\frac{1}{2}$ in.
Distance apart	11ft. centres
Thickness	11in.
Size of Piers	9in. $\times$ $4\frac{1}{2}$ in.
Distance apart	11ft. centres

Reinforcement—

In Foundations	$\frac{1}{2}$ in. and $\frac{5}{8}$ in. bars.
In Retaining Walls	$\frac{5}{8}$ in. and $\frac{3}{4}$ in. bars.
In Counterforts	$\frac{5}{8}$ in. and $\frac{3}{4}$ in. bars.
In Piers	$\frac{5}{8}$ in. bars.

*Beams—Dimensions :—*8in. $\times$ 7in., 11in. $\times$ 7in., and 11in. $\times$ 11in.

Reinforcement— $\frac{3}{4}$ in. and $\frac{5}{8}$ in. bars.

11in. $\times$ 11in.	12 $\frac{1}{2}$ lb. steel per ft. lin.
11in. $\times$ 7in.	5 lb. steel per ft. lin.
8in. $\times$ 7in.	4 $\frac{1}{2}$ lb. steel per ft. lin.

Roof Slab—

Thickness—5in.

Reinforcement— $\frac{7}{16}$ in. bars at 6in. centres, with diagonal shear bars at 3ft. centres.

All bars are connected by steel clips. Roof covering—Limmer Asphalte. The combined live and dead load allowed for was 2 cwt. per sq. foot. The concrete was 1 : 2 : 3, as before.

Cost—

Retaining Wall (Tender)	..	..	£197	0s.	0d.
Roof	..	..	£296	12s.	5d.

(3.) AUTHOR'S CALCULATIONS TO ASCERTAIN THE STRENGTH OF R.C. RETAINING WALLS AT BEACONSFIELD LAVATORIES, BRIDLINGTON :—

COUNTERFORTS.

The equations used satisfy the statical conditions required for any piece subjected to flexure ; namely the total compressive force above its neutral axis is equal to the total tensile force in the tensile reinforcement. The resulting stresses are proportional to the distance from the neutral axis and the moduli of the two materials.

K = The distance in inches of the neutral axis from top of table.

$$m = \frac{\text{Modulus of steel}}{\text{Modulus of concrete}} = 15.$$

B = Breadth of table in inches.

Ac = Area of steel in compression in $\square''$.

At = „ „ tension in $\square''$.

H = The distance in inches from centre of tensile reinforcement to top of table.

b = The distance from c.c. to top of table in inches.

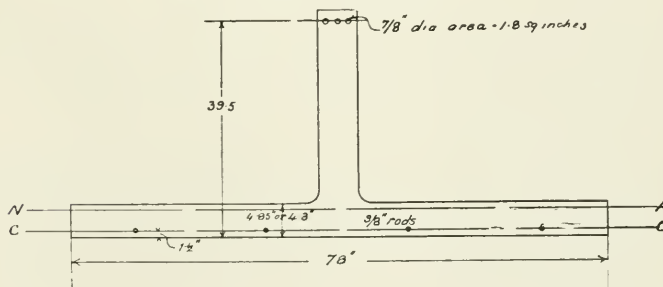
c = Stress in concrete in lbs. per $\square''$.

St = Tensile stress in steel in lbs. $\square''$.

Sc = Compressive stress in steel in lbs. $\square''$.

M = The momental resistance of the section in lb. inches.

NA is the neutral axis.



$$K = \frac{m}{B} (Ac + At) \left[\sqrt{1 + \frac{2B(bAc + HAt)}{m(Ac + At)^2}} - 1 \right] =$$

$$\frac{15}{78} (0.44 + 1.8) \left[\sqrt{1 + \frac{156 \times (.66 + 71)}{15 \times (2.24)^2}} - 1 \right] =$$

$$\frac{15}{78} \times 2.24 \times 11.25 = \underline{4.85''}$$

Taking stress in steel as 16,000 lb. $\square''$ then $cm. \frac{4 \times K}{K} = 16,000$

$$= c \times 15 \frac{39.5 - 4.85}{4.85} = 107c \text{ and } \underline{c = 150 \text{ lb. } \square''}$$

$$M = \frac{c}{K} \left[\frac{K^3 B}{3} + m \{ Ac (K - b)^2 + At (H - K)^2 \} \right] =$$

$$\frac{150}{4.85} \left[2960 + 15 \{ .44 (3.35)^2 + 1.8 (34.65)^2 \} \right] =$$

$$\frac{150}{4.85} \left[2960 + 15 \times 2165 \right] = \frac{150}{4.85} \times 3546 = 1,095,000 \text{ in. lb.}$$

or 40.5 ton ft.

Using $\frac{3}{4}$ rods for tensile reinforcement area $1.325 \square''$

$$K = \frac{m}{B} (Ac + At) \left[\sqrt{1 + \frac{2B(bAc + HAt)}{m(Ac + At)^2}} - 1 \right]$$

$$= \frac{15}{78} (0.44 + 1.325) \left[\sqrt{1 + \frac{156}{15} \times \frac{.66 + (39.5 \times 1.325)}{(.44 + 1.325)^2}} - 1 \right]$$

$$= \frac{15}{78} \times 1.765 \left[\sqrt{1 + \frac{156}{15} \times \frac{52.86}{3.1}} - 1 \right]$$

$$= 0.34 \times 12.7 = 4.3 \text{ ins.}$$

$$cm \times \frac{HK}{K} = 16,000. \quad c = \frac{16,000 \times K}{m(H - K)} = \frac{16,000 \times 4.3}{35.2 \times 15} = \underline{130 \text{ lb. } \square''}$$

$$M = \frac{c}{K} \left[\frac{K^3 B}{3} + m \{ Ac (K - b)^2 + At (H - K)^2 \} \right]$$

$$= \frac{130}{4.3} \left[\frac{79.4 \times 78}{3} + 15 \{ .44 (2.8)^2 + 1.325 (35.2)^2 \} \right]$$

$$= \frac{130}{4.3} \left[2060 + 15 \{ 34.5 + 1640 \} \right] = \frac{130}{4.3} \left[2060 + 15 \{ 1674.5 \} \right]$$

$$= \frac{130}{4.3} \left[2060 + 25,010 \right] = \frac{130}{4.3} \times 27,070 = 820,000 \text{ in. lb. or}$$

30.5 ton ft.

LOAD ON COUNTERFORTS, &c.

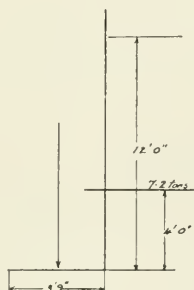
Using Rankine's formula for pressure P_B per $\square'$ at base of retaining wall with W = weight in pounds of 1 cub. ft. of earth, and h = the height of earth above base. Then—

$$P_B = Wh \cos \theta \frac{\cos \theta - \sqrt{\cos^2 \theta - \cos^2 \phi}}{\cos \theta + \sqrt{\cos^2 \theta - \cos^2 \phi}}; \quad \theta = 0$$

$$\text{and } P_B = Wh \frac{1 - \sqrt{1 - \cos^2 \phi}}{1 + \sqrt{1 - \cos^2 \phi}} = Wh \frac{1 - \sqrt{\sin^2 \phi}}{1 + \sqrt{\sin^2 \phi}} = Wh \frac{1 - \sin \phi}{1 + \sin \phi}$$

Taking an average value for the angle of repose, $\phi = 32^\circ$ and weight of earth 1 cwt. per cubic ft.

$$P_P = 112 \times 12 \times \frac{1 - \sin 32^\circ}{1 + \sin 32^\circ} = 112 \times 12 \times \frac{1 - 0.53}{1 + 0.53} = 112 \times 12 \times \frac{0.47}{1.53} \\ = \underline{413 \text{ lb. } \square'}$$



If Pt = the horizontal thrust

$$Pt = \frac{413 \times 12' \times 6.5'}{2} = 16,100 \text{ lb. or } \underline{7.2 \text{ tons (approx.)}}$$

The centre of pressure is $\frac{1}{3}h$ from base = $\frac{12}{3} = 4 \text{ ft.}$

The bending moment Bm on Counterfort = $4 \times 16,000 \times 12$
768,000 lb. inches or 28.6 ton ft.

The moment resisting overturning as shewn sketched is:—

$$\frac{12' \times 112 \times 3.75' \times 6.5'}{2,240} \times \frac{3.75}{2} = \underline{27.4 \text{ ton ft.}}$$

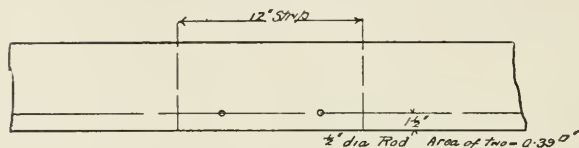
as against $7.2 \times 4 = \underline{28.8 \text{ ton ft.}}$

$28.6 - \frac{1}{4} \times 12 = \underline{25.6 \text{ ton ft.}}$, and the overturning moment
25.6 ton ft. against a resisting moment of 27.4 ton ft.

SLAB BETWEEN COUNTERFORTS.

$$K = \frac{m A t}{B} \left[\sqrt{1 + 2 \frac{B H}{m A t}} - 1 \right] = \frac{5.85}{12} \left[\sqrt{1 + \frac{2 \times 12 \times 3.5}{15 \times .39}} - 1 \right]$$

$$= \frac{5.85}{12} \left[\sqrt{15.35} - 1 \right] = \frac{15 \times .39}{12} \times 2.92 = 1.42''$$



If steel is put 1" from underside of slab, then—

$$K = \frac{15 \times .39}{12} \left[\sqrt{1 + \frac{2 \times 12 \times 4}{15 \times 0.39}} - 1 \right] = .488 \times 3.18 = 1.55$$

say with steel at $\frac{7}{8}$ " from underside 1.6"

$$St = c m \frac{H - K}{K} = 16,000 = c \times 15 \frac{4.15 - 1.6}{1.6} = \frac{2.55}{1.6} \times 15 c = 16,000.$$

$$c = \frac{16,000 \times 1.6}{15 \times 2.55} = \underline{670 \text{ lb. sq"}}$$

$$M = \frac{St A c}{3} (3 H - K) = \frac{16,000 \times 0.39}{3} (3 \times 4.15 - 1.6)$$

$$= 16,000 \times 0.13 \times 10.85 = \underline{22,500 \text{ lb. ins.}}$$

If L is the span in feet between the counterforts and D the depth in feet, then the vertical reinforcement should be:—

$$\frac{A t L^2}{D^2} = \frac{6.5^2}{12^2} \times 0.39 = 0.114 \text{ sq"}$$

With slab of unit breadth (12in.) and supported at ends, loaded with a uniform load of W lb. per foot run, the usual equation for the bending moment is $B m = .125 W L^2$. Where L = the span in feet with the slab supported as above and w the maximum load per sq. ft. at the base. The maximum bending moment $B m = .045 w L^2 = .045 \times 413 \times 6.5^2 = 783 \text{ lb. ft.} = 9,400 \text{ lb. inches.}$

(4.) THE FINISHING OF EXPOSED SURFACES IN CONCRETE.

One of the greatest difficulties of an engineer or architect in carrying out reinforced-concrete work is to avoid on the finished face of his concrete, ridges, bulges, grain marks, projections, and small holes. These imperfections can be con-

siderably modified by the proper construction of the moulds, and this part of reinforced-concrete construction, the Author contends, has not received the attention that it should have done. Another very important matter in connection with the endeavour to avoid these imperfections is the necessity of placing the concrete in the moulds with the greatest care, and well consolidating same; it is unwise to attempt to rush this work with a view to being able to accomplish a certain number of superficial yards of walling or foundations or other work per day. Variations in the colour of the finished surface also have to be dealt with. Dirt adhering to the moulds will frequently cause this. As this paper deals chiefly with reinforced-concrete retaining walls, the Author will treat only of the finishing of the face of same. If it is required to finish the wall with a smooth face, and the wall is not intended to be rendered, it is advisable to use carefully planed boards for the forms; if this is not done the slightest imperfections in the face of the forms will be reproduced on the plastic mixture when it hardens, as will also the joints between the boards, and the grain in the timber will leave its impression. It is practically impossible to construct the forms so that no slight impression occurs, but it is certainly desirable that only straight grained, smoothly planed timber should be used, and that the forms should receive a coat of soft soap before use.

When the forms have been removed the Author's experience has taught him that the grain marks, joints between boards, and other imperfections can easily be removed by rubbing down the surface with sand paper, after taking off the projections with a chisel. It is a good way of finishing the wall to adopt the course set out in the specifications for concrete presented by the Special Committee of the Engineering and Maintenance of Way Association, U.S.A., which is as follows:—

“After the forms are removed, any small cavities or openings in the concrete shall be neatly filled with mortar if necessary. Any ridges due to cracks or joints in the shuttering shall be rubbed down, and the entire face shall then be washed with a thin grout of the consistency of whitewash, mixed in the proportion of 1 part of cement to 2 parts of sand. The wash shall be applied with a brush.”

The Author usually finishes his reinforced-concrete walls in the foregoing manner, unless these walls occur in a building, when he recommends finishing in the following manner:—Dress down the face, and apply a thin coat (less than $\frac{1}{2}$ in. and merely skimming) of Parian cement; this makes an excellent finish. The underside of the roof of Beaconsfield Lavatories was finished in this way. It should perhaps be mentioned that American engineers deprecate the practice of plastering walls; their contention being that cement rendering will not adhere for any

length of time to a concrete surface, and the Author agrees with them in this matter.

Pebble Dash Facing.—In the United States one may occasionally see the face of reinforced-concrete walls pebble dashed, this being done in the following manner:—

Large rounded stones are used in place of the usual aggregate for the surface layer of concrete, and while the concrete is still plastic, the mortar between the pebbles is removed by wire brushing until about half the pebbles are exposed. In the concrete road-bridge at the National Park at Washington the walls are finished in this way, the Specification for this work being as follows:—*

“The concrete, which will be in the exterior faces of the bridge and the parapet walls for a thickness of 18in. will be made of gravel and rounded stone, varying in the concrete below the belting course between 1½in. and 2in. in their smallest diameters. This gravel will be mixed in the concrete as aggregate instead of broken stone. The mixture will consist of 1 part Portland cement, 2 parts sand, and 5 parts of aggregate. The parapet walls will be made in a similar manner, with the aggregate composed of gravel not exceeding 1in. in its smallest diameter. When the forms are removed the cement and sand must be brushed from around the face of the gravel with steel brushes, leaving approximately half of the gravel exposed.”

The brushing took place after the concrete had had a 24 hours' set. After a 12 hours' set it was found that the concrete would not hold the pebbles, as it was not sufficiently hardened, and after a 36 hours' set it was too hard to permit the brushing.

Tooled Surfaces.—Concrete surfaces are often dressed with hammers and chisels after hardening, similar to stone dressing, and any of the methods of finishing cut stone is suitable for finishing concrete.

Masonry Facing.—On reinforced-concrete arch bridges a masonry face is sometimes employed, and this may be of any style of stonework.

Ornamental Shapes in Retaining Walls.—There is no reason whatever why ornamental shapes should not be introduced in the construction of reinforced-concrete retaining walls, in fact this is often done in America, and on the Continent.

(5.) MAKING CONCRETE WATERPROOF.

During recent years many experiments have been made for the purpose of ascertaining by what means concrete may be made absolutely watertight, not only under ordinary conditions, but also when under pressure, as obtains in reservoirs, conduits, dams, etc. In the United States the waterproofing most used consists

* “Reinforced Concrete,” by Buel and Hill, pages 421-422.

of a layer of asphalte made by mopping hot asphalte into the concrete until a coat from $\frac{1}{4}$ to $\frac{1}{2}$ in. thick is formed. The objection, however, to this is that asphalte exposed to the action of water has but a short life. Some American engineers advocate and adopt the following practice :—The face of the wall or dam is plastered with semi-liquid mortar, consisting of—

- 1 part Portland cement,
- $\frac{1}{2}$ part of thoroughly slacked lime,
- 3 parts sand,

When this has well set, a coat of pure cement grout is applied.

Many other methods might be described, such as the application of a compound of alum and soap, recommended by Prof. Ira O. Baker*, but the Author's opinion is that while these may appear satisfactory in laboratory tests, they cannot be relied upon in actual work.

What, then, is the best way of rendering concrete watertight ? It lies in the direction of improved methods of mixing and placing concrete, a more careful selection of the aggregate, especially as regards its size. The Author is greatly in favour of "wet" concrete being used wherever the finished work has to be watertight. Better provision should also be made in designing reinforced concrete structures for shrinking due to temperature changes. Additional mixing would doubtless cost more, but if the purpose aimed at can thus be attained, the first cost would be the last.

If the foregoing matters were thoroughly attended to, experience shows that a concrete may be made which is quite impervious. On no account should a "dry" concrete be made if intended to be watertight.

In the case of long retaining walls, leakage cracks may be prevented by the proper placing of horizontal and vertical reinforcement, and the wall would be quite waterproof, that is, provided the concrete itself is impervious.

(6.) EXPANSION JOINTS.

In walls of large cross-sectional area and considerable length it is advisable to provide for contraction and expansion by inserting expansion joints. Undoubtedly the cracks which one often observes in long walls of concrete could have been avoided had a precaution of this kind been taken.

(7.) TYPICAL EXAMPLES OF REINFORCED-CONCRETE RETAINING WALLS IN THE U.S.A.

Figs. 1 to 7 have already been briefly described. Fig. 8 represents a counterforted wall built with a wide foundation on which the weight of the embankment rests. In this particular example a precaution has been taken to prevent the wall from

sliding forward on its foundation. This is a typical section of a wall built by the Great Northern Railway of America.

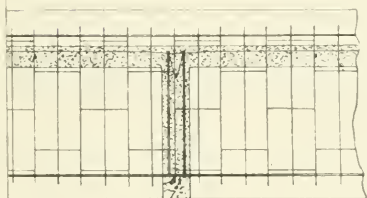
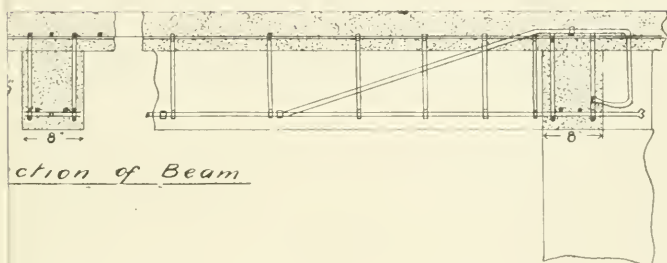
Fig. 9 represents a reinforced-concrete retaining wall built by the New York, Ontario and Western Railway as a wing wall for an abutment. It varies in height from 26 to 35ft.

Fig. 10 represents a wall designed by the Condon and Sinks Company, Consulting Engineers. It has been erected for Marion County, Indiana, and is about 800ft. in length.

Fig. 11 represents a wall designed for the Union Railway Co., at Memphis, Tennessee. It is 500ft. long and was built in 1907. The cost, including excavation, was \$7,527 or \$6,118 without excavation. The cost per cubic yard of concrete, including reinforcing, was \$8.82.

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AUGUST, 1910.

G WALL AT BRIDLINGTON.



section of the wall of this building is
to that shewn in Fig. 7.

MATTHEWS ON REINFORCED-CONCRETE
RETAINING WALLS

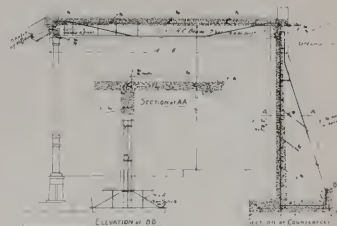
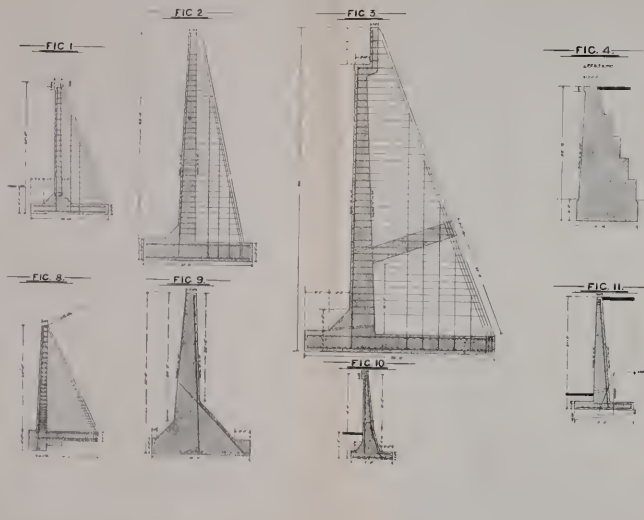


FIG. 5.

REINFORCED CONCRETE RETAINING WALL AT BRIDLINGTON

FIG. 6

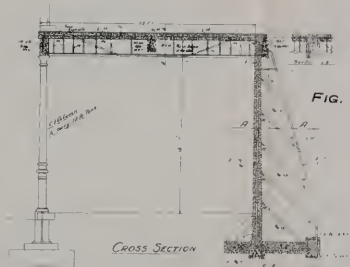
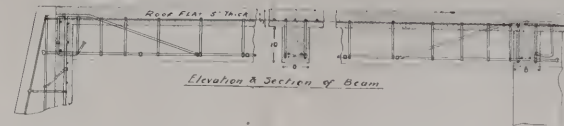


FIG. 7.



ELEVATION (AT BACK)



Counterfort with Section & Plan of foundations

NOTE: The cross-section of the wall of this building is similar to that shown in Fig. 7.

ENGINEERS AND EMPIRE DEVELOPMENT.

Mr. C. Reginald Enock replies briefly to the correspondence on his paper (published in a recent number of the JOURNAL) as follows:—"I was glad to see some comment upon my paper, although no doubt engineers as a whole are too busy to give much time to the discussion of matters of policy. Mr. G. A. Becks enters very much into the substance of the principle and plan I brought forward. Mr. P. G. Scott rather wanders away from it to a plan of organisation among engineers themselves. This, whilst certainly advisable, must be looked upon as a detail. Organisation of existing conditions is not sufficient. What we require to do is to create a new field, to take in new resources and not to be in-feeding, as it were, upon what exists and what is insufficient for all. If, as engineers, we look around us, we shall see that our railways, roads and buildings are largely built, that our land is all owned, that this island, from reasons both geographical and economical, is become too restricted for its people. On the other hand we own an enormous unexploited field in our Colonial possessions, such as no other nation possesses. But it is no longer sufficient to permit this to be exploited by purely haphazard, nepotic, or selfish methods, or for private interest on a Stock Exchange basis. We must take hold of it in the public interest, not by despoiling anybody, but by creating new centres of industry and new sources of revenue out of what is at present undeveloped territory. It is a reflection on our intelligence that unemployment and insufficiency should be so prominent in our midst, when we are the masters of these available resources, which, under the influence of capital and work of engineers, might provide a field for every worker and increase the national wealth.

"I hope further thought will be given by the Society to this subject. To those interested in a more detailed exposition of the plan put forward, I venture to bring to notice my book 'An Imperial Commonwealth,' now being published (Grant Richards), and I am also to give several lectures upon the subject of Empire development before various Societies. Further, I am working to establish a 'British Association for Imperial Development,' to accomplish for the industries of Britain and the Empire what the famous British Association does for Science, and to educate the public to a knowledge of the Colonial resources and

their opportunities therein. I have brought forward the proposal that an expert Council or 'parliament' should be constituted to control this body, formed of (paid) delegates from all our learned, commercial, educational and other institutions."

VISIT TO THE THAMES IRON WORKS.

On Wednesday, September 7th, 1910, the fifth vacation visit of this session was made, by the courtesy of the company and with the permission of the Admiralty, to the works of the Thames Iron Works, Shipbuilding and Engineering Co., at Canning Town, E.

These works, which cover an area of 26 acres, include Shipbuilding, Civil Engineering, Electrical Engineering and Dry Dock Departments, and are equipped with tools and plant ranging from those of the heaviest description used, in the construction of battleships and massive constructional work, down to the smallest of automatic tools for the making of electrical fittings and switch parts.

Starting at the river frontage near to the General Offices, the first department passed through was the Dry Dock Department. Here are situated the two Dry Docks, the larger 475ft. long, with a depth of 22ft. over the cill, the smaller 335ft. long, with a depth of 19ft. over the cill, with their self-contained repairing shops.

The Electrical Engineering Department has its main shops in the same building as the General Offices, and has a large output of general electrical work. The Central Station, situated nearer the middle of the Yard, is equipped with a 250 k.w. motor transformer set for converting the Borough Council supply at 500 volts to 220 volts, to suit the Yard service. Independent stand-by sets, capable of supplying the power and lighting for the Yard in case of failure of the Council service, are also installed, and a battery of powerful air compressors will be seen for the supply of power to the numerous pneumatic tools in use.

The Shipbuilding Department is laid out for the construction of vessels of the largest type now building, vessels of all sizes being represented among those which have been launched from these works, including ships for our own and most of the other navies of the world, to the number of close on 900, and in the General Offices is kept part of a collection of models of past jobs, interesting alike from an historical or engineering point of view. H.M.S. "Warrior," the first iron sea-going armour-clad in the

world, was built here, and the march of progress of naval construction might well be gauged by a study of the vessels built here alone, practically every type having been represented.

In the shipyard can be observed the marked progress which has been made with the hull of H.M.S. "Thunderer." The outer skin of the vessel is practically complete up to the protective deck, while above are being erected the frames and plating to which the side armour will be attached later.

Passing out of the Shipbuilding Department at the north end of the Yard, the Civil Engineering Department is reached. Here Bridges, Piers, Dock Gates, Caissons, Structural Work, Roofing, and other similar works involved in civil engineering projects at home and abroad are dealt with, among recent examples being the sixteen large sliding and floating caissons for 95ft. entrances at H.M. Dockyards at Keyham, Gibraltar, and Hong Kong, and three pairs of Dock Gates for the 90ft. entrance to King's Dock, Swansea.

The work now in progress includes the steel and iron work for the Wharfing for Tanjong Pagar Docks at Singapore, comprising 8ft. diameter wrought-iron cylinders, carrying box and plate girders as a superstructure, on which the heavy trough flooring rests. Some 6,000 tons of the work have already been despatched. The steel and iron for the Wharf at West Mole, Lagos Harbour, to the order of the Crown Agents for the Colonies, also in hand, includes cast-steel screws, wrought-iron piles and bracings, carrying a superstructure of steel girders covered with a timber floor. The clips for this are being pressed in the hydraulic presses, and near by is the testing machine, in which each screw is subjected to a test load of 90 tons before despatch.

In this department also the pontoon and substructure for a 150-ton floating crane for use in fitting out H.M.S. "Thunderer," including boilers, pumps, winches, and deck fittings, are being constructed, the pontoon having already been launched and the work now proceeding afloat.

The hull is rectangular in plan, 97ft. by 76ft., and the depth 14ft., the inside being divided by water-tight bulkheads into a large number of independent compartments, ballast chambers, boiler and pump rooms, etc. The crane is designed to lift 150 tons at a distance of 56ft. from the pontoon, and lighter loads at proportionate radii up to an outreach of 105ft. from the pontoon.

Other work includes ten spans of 50ft., each weighing about 25 tons, and the steelwork for two skew-span bridges 60ft. and 67ft. 9in. long respectively, comprising 150 tons, for the Central South African Railways.

VISIT TO THE ENGINEERING EXHIBITION AT OLYMPIA.

In response to a courteous invitation by the management of the Naval, Mercantile Marine, and General Engineering and Machinery Exhibition a large party of members of the Society and their friends (including a number of ladies) assembled at Olympia, on Wednesday, September 21st, 1910, to view the many interesting exhibits displayed there by various firms. After making the round of the Exhibition, the visitors assembled in the Pillar Hall, where they were received by Sir David Gill, K.C.B., F.R.S., President of the Institute of Marine Engineers and of the Exhibition. Tea was then served, at the conclusion of which Sir David Gill addressed a short speech of welcome to the members of the Society, which, in the unavoidable absence of the President, was responded to by Mr. E. J. Silcock, M.Inst.C.E., F.G.S., Past President of the Society of Engineers, who expressed the pleasure which it gave the members to have an opportunity of viewing the objects of engineering interest comprised in the Exhibition, and thanked the management for the hospitality which they had extended to their visitors. A further inspection of the exhibits was then proceeded with, and terminated a very enjoyable and instructive visit.

SOME ENGINEERING TROUBLES IN AFRICA, AND THEIR SOLUTIONS.

By GEORGE A. BECKS, ASSOC.M.INST.C.E.

[MEMBER.]

THE author desires to state at the outset that this paper is not intended to be a masterpiece of literary effort, nor what is generally known as "a very valuable paper," but rather a brief note of some difficulties met with abroad, from which some ideas may be gained regarding the erection of machinery in undeveloped countries.

The author is pleased to say that difficulties are likely to arise in most engineering undertakings; if it were otherwise, "the art of directing the great sources of power in Nature for the use and convenience of man" would not permit many to earn a livelihood. Difficulties abound, and engineers exist for the express purpose of overcoming them and bringing into operation the special knowledge gained by engineering training and experience. The author therefore takes no credit for carrying out the work for which he was paid, and which he was, by reason of his training, enabled to perform satisfactorily where others, by reason of their inexperience, and perhaps lack of physical strength and health, had failed or died in the attempt. The significance of this last remark is that the work here described was executed on the West Coast of Africa, which has no very enviable reputation as a health resort.

The Government of Lagos, Southern Nigeria, having decided, principally in the interests of the white population, that it would be to the advantage of the Colony to ameliorate the lot of the residents as far as possible, and to do all that could be done to save life, instructed their home agents to procure and forward an ice-making and refrigerating plant, chiefly intended for the use of fever patients in the hospital, and, incidentally, to allow a fair margin for contingencies. The author need not enlarge upon the contingencies; suffice it to say that a little bit of ice in them makes them more palatable after one has been for some hours in the blazing sun.

The agents then put the matter in the hands of the late Mr. W. Harry Stanger, whose chief mechanical assistant it was the privilege of the author to be at that time, and from whom he took his instructions. At the outset of investigations it was discovered that there was an insufficient supply of water, so that the question of obtaining that health-giving and necessary fluid became paramount. True, there was a well close to the pro-

posed site, but the liquid it contained was both insufficient in quantity and deficient in quality, though at seasons it would deliquesce and become sufficiently plastic to take the form of a containing vessel. It could even be pushed through a sharp bend in a pipe without snapping, but it was not suitable for refrigerating purposes.

To overcome this trouble it was necessary that a distilling plant should form part of the installation, with pumps to draw a supply of water from the lagoon, a distance of about 450ft., with, fortunately, a rise of only about 1 in 45, all surplus water being run back from whence it came. The distilling plant consisted of an evaporator, which was really a vertical boiler working at about 5 lb. pressure per square inch, fired by petroleum fuel from a supply tank placed on the floor above. The vapour rising from the boiler entered a coil immersed in water, also situated on a higher level, where it condensed and flowed to another tank placed conveniently over the ice-making tank on the ground floor.

The belt-driven main pumps delivered the brackish water from the lagoon into a large tank situated at the top of the tower, from whence it flowed by gravity both to the evaporator and condensers. The motive power for the entire installation consisted of a Priestman oil engine using ordinary petroleum, as it was thought advisable not to have steam power on account of the scarcity of fuel and the additional cost of a boiler and attendant.

The refrigerating plant was supplied by the Linde Company, and was of their ordinary type, working by a belt from shafting driven by the oil engine. The refrigerant used was ammonia, condensed in the open air in coils, over which trickled a constant supply of water. The ice tank, containing sufficient moulds to produce a ton of ice daily, was built into a chamber, carefully insulated all round, and having a zinc covering to the floor. The thawed ice escaped by means of a trap, which always contained a certain amount of water, thus preventing the outside air from entering, which would have enhanced thawing. The ice tank, thus forming a large body of "cold," kept the inside of the ice storage chamber at a low temperature, in this way materially assisting the preservation of the ice after its removal from the moulds. The refrigerating medium surrounding the ice moulds was a solution of chloride of calcium, kept in constant circulation by means of a small rope-driven propeller.

The foregoing is a brief description of the actual machinery used, but as this paper is intended for engineers there is no need to enlarge further upon it, nor to enter into details of construction, areas of surfaces, output and efficiency, etc., all of which vary according to local conditions. The author will therefore proceed to the subject matter about which he proposes to write, namely, difficulties experienced and surmounted, which to him,

as a practical engineer, are usually of much greater interest than commonplace and technical details.

The first problem arose after putting the engine on to its foundations, and that was how to get the fly-wheel on to the crankshaft. This wheel weighed 1 ton, and there was no place in the roof of the building strong enough to allow of the fly-wheel being lifted by means of tackle. It was therefore rolled along the ground by natives, in momentary danger of falling over, till it stood opposite the end of the shaft. A stout plank having been placed for it to rest upon, the wheel was "scotched," and guys fixed from its upper rim to each side of the engine room. The supporting plank was then pinched up about an inch, first at one end and then at the other, packing being put under at each lift, till finally the bore of the wheel stood fair with the shaft. A jack was then brought to bear on the plank sideways, while the guy ropes were repeatedly slackened and taken up, so that eventually the wheel rode in place, and was keyed up. The author would here remark that never again, if he can avoid it, will he have ONE fly-wheel of such weight on one end of a crankshaft without another one on the opposite end, unless it be supported by an outer bearing, as great trouble was afterwards caused by the bearing adjacent to the wheel becoming heated.

The next trouble was due to the fact that the engine had been sent out considerably in advance of the remainder of the plant, in fact, it was sent out before the building was erected, and stood unpacked and uncovered alongside its foundations, while rain, dust, cement, and the like showered upon it, so that after erection it was not in first-class condition for running; and while turning the fly wheel, prior to cleaning up, the air-pump rod was bent on account of the plunger becoming fast in its cylinder. This necessitated straightening the rod, which, being polished and turned, would have been badly marked if put into an ordinary smith's fire, so the author had a fire made with wood fuel only, which does not destroy a polished surface. This hint may be useful to young engineers who have not heard of it before.

A great deal of trouble was experienced in connection with the firing of the compressed oil gas in the cylinder. This firing was electrical, and it was only after considerable delay that failure to spark was traced to the battery, and the author would like to thank the representative of the African Telegraph Company, who lent him suitable means of tracing the fault. In view of this, it is desirable that all engineers who may be about to erect electrical-firing engines in half-developed parts of the world should be equipped with suitable testing instruments.

A difficulty which presented itself to the author before he left for Southern Nigeria (for it will be understood that he was deputed not only to arrange the plant but also to supervise its erection) was the question of erecting the main water storage

tank at the top of the tower. This tank was built of steel plates, and was to be made and riveted up complete before shipment. Its weight empty was about three-quarters of a ton and about 4 tons when filled.

The building being finished and the roof on, prior to the author's arrival in the Colony, it was not possible to lift the tank over the top, nor could it be passed through the window, and as the tank was practically the same width as the inside of the tower, the difficulty of erecting it became at once apparent. The author, therefore, decided upon what was, to him at all events, a new method of erection, namely, to begin at the top and work downwards. A strong beam was placed in the brickwork across the centre of the tower at the extreme top, and the tank had a stay of unusual strength fixed across its middle. These simple precautions made the work of erection quite straightforward, the tank being rolled to the bottom of the tower inside, blocks and falls attached to the wooden beam at the top and to the stay in the tank, and the end of the falls passed through the top window, so that native labourers could haul upon it. By these means the raising was easily done.

Prior, however, to hoisting the tank the steel joists which were to support it had been placed in the brickwork from the outside, just so far as to leave their ends flush with the inside of the tower walls, and there they hung like cantilevers till the tank had reached its top level. The joists were then moved right through the tower into corresponding holes on the other side, where stone templates had been provided for the joists to rest upon, tarred felt being slipped in under each end. The tank was lowered a few inches till it rested on the joists, and the deed was done, the holes in the brickwork being afterwards built up. The fresh water distilling tanks and coils were suspended in a similar way from the joists just mentioned and the flooring built under them.

The author would recommend this method of erecting plant in similar situations, as it is at once simple, rapid, and effective, dispensing with scaffolding, cranes, and every form of lumber except a plain block and tackle. Trouble may be anticipated, however, when some unfortunate engineer receives orders to dismantle the place.

A suggestion in connection with the transportation of heavy loads along soft and sandy roads might here be made with advantage. It should be borne in mind that the author had no animal power available, neither had he a truck strong enough to carry the heavier parts of the plant. The distance the material had to travel to the site being about three-quarters of a mile, rollers and pinch bars were, to say the least, not conducive to rapid transit, but by getting several rollers, a sling round the cases in a horizontal direction, blocks and falls, and an anchor, which latter was

placed in the road as far ahead as the falls permitted, the loads went along beautifully till a fresh pitch had to be made for the anchor owing to the blocks getting "chock-a-block." The idea may not be original, but the author had never before seen it put in practice, so that even now it may be new to some people.

A very important point to remember is one which the author learned through much tribulation and vexation of spirit. It is this: Ascertain for certain the custom of any country as regards the thickness of brick walls before arranging the details of work which may pass through them from one room to another. The author designed the Lagos building before this point was ascertained, and arranged for 14in. external and 9in. internal walls in accordance with English practice, and all connections of pipes, etc., were made for these dimensions. On his arrival in the Colony he discovered that it was the local custom, on account of inferior bricks, to make all walls 18in. thick, and the trouble that arose in consequence may be imagined.

The upsetting of plans was heartbreaking, as practical engineers will readily understand. Centre to centre distances between different parts of the building were all from 4in. to 9in. out, pipe flange connections being shockingly wrong, so that all well laid lines of direction had to be abandoned, and the system re-designed, using only the material which was at hand, as there was no chance of obtaining any more, while in the case of some of the wrought-iron pipes of the larger dimensions additional short pieces had to be put in, and in the absence of screwing tackle for these sizes, the joints were made by slipping sockets over the pipe ends and soldering them up. Fortunately, no pipes which had much pressure to carry had to be so connected.

As stated in the early part of this paper, the water supply was drawn from the lagoon, a double line of pipe being laid. The pipes were ordinary cast iron with faucet and spigot joints, these being made with spun yarn and lead, well caulked. This form of joint should be avoided in sandy districts, for, in the event of stoppage, the difficulty of opening up the mains is considerable, in fact, they have to be cut. The flange joint is therefore preferable.

In an installation of this kind, where temperature enters largely into the work, the question of keeping everything as cool as possible is one which should not be overlooked. Fortunately, in Lagos vegetation is of very free growth, and shade trees were therefore planted close to the doors of the building and in front of the ammonia condenser, to afford protection from the sun's rays. In Lagos, if you want a tree, all you have to do is to select some branch of convenient size and shape which you may find growing on another tree, cut it off, put the stump in the ground, and it will grow.

A final point to remember in large installations of pipe work

is to be sure to clear every pipe before putting it into use. The author was seriously hampered for several days after starting to work the plant through not taking this precaution. A small cockroach crawled through the pipes as far as it could, and blocked up the fine ammonia regulating valve, upsetting the readings of pressure as shown by the gauges, and the general working of the plant, so that after it had been removed 45 lb. of ammonia had to be taken from the system. This was done by connecting an empty ammonia drum to the delivery side of the compressor, close to the condenser, keeping it cool by a constant spray of water.

The foregoing is an outline of the principal troubles met and overcome in connection with actual mechanical matters on this particular work, but it does not by any means indicate the whole of the author's worries. When it is remarked that the native bricklayers will set only 100 bricks in a day, and so-called fitters cannot be trusted even to tighten up a nut, cut a thread, or screw two pieces of pipe together, that the natives hardly understand a word of English, that the climate makes a white man feel a worse wreck to-morrow than he does to-day, and that every incident sends his temperature up a degree or two, the pleasure of having the end of the work in sight will be understood.

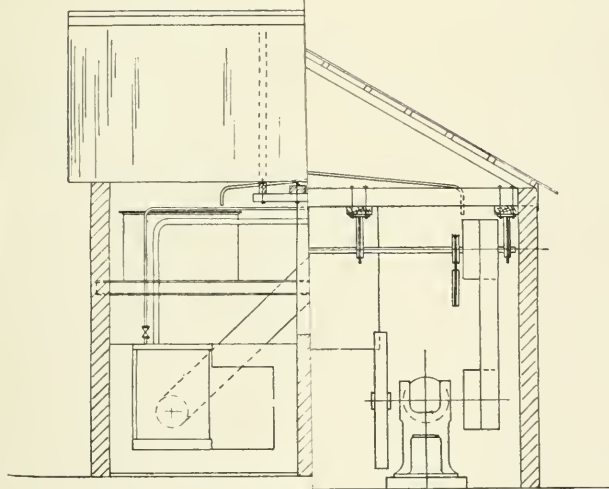
But the most anxious time for the author on this trip was when the plant commenced actual running. Many times had he been told that his attempt would fail, even before he started work, as all previous attempts on the West Coast had come to grief; but having already dealt successfully with a plant which had failed in Natal, he felt confident of success in Lagos. His Excellency the Governor, who was travelling up country, had been privately informed that the "glacial epoch" was approaching, so it had to come.

The engine left off playing tricks and worked well, all joints were sound, and the "opening day" arrived. Backwards and forwards the author went to and from the ice tank to look at the thermometer, down and down went the temperature through nearly 65 degrees, ice began to form in the moulds, till towards evening they were frozen up.

The first ice ever made in Nigeria! The Governor had the first block immediately it was removed, and a sick man had the second one. The natives crowded round and felt it with numerous "Wows!"

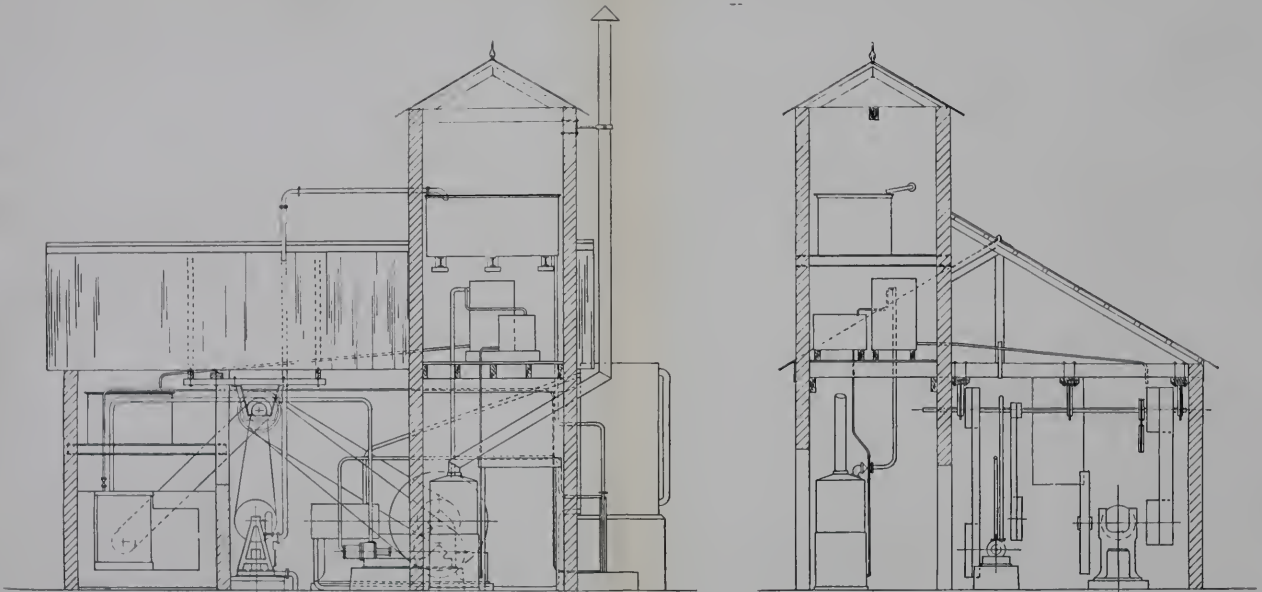
The author returned to England with the satisfaction of knowing that his success would mean the saving of many valuable lives.

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G. A. BECKS on
Some Engineering Troubles in Africa.



SECTIONS OF ENGINE HOUSE.

Journal of the Society of Engineers
(Incorporated).

September, 1910.

October 3rd, 1910.

DIOGO A. SYMONS (PRESIDENT)

IN THE CHAIR.

CURRENT PROFESSIONAL TOPICS.

By HENRY C. ADAMS, ASSOC.M.INST.C.E., A.M.I.MECH.E.,
A.M.I.E.E., ETC.

[FELLOW.]

THERE are many subjects of professional interest to an engineer which from time to time acquire a certain degree of prominence, even being hotly debated at meetings of the various scientific societies, and then are allowed to drop into oblivion without any definite advancement having been made, but the recurrence of such topics is indicative of a general state of unrest in the profession. Recently the status of the engineering profession has received considerable attention and many suggestions have been put forward by which the condition of engineers may be ameliorated, but while the author does not propose to deal with this subject as a whole at present, he would suggest that the first step is to diagnose the complaint and then to devise a workable scheme for its cure. It is useless merely to deal with the symptoms and leave the root of the ailment untouched. There are "quacks" in all walks of life, and those ignorant, unqualified men that one finds doing engineering work cannot be included or considered as members of the engineering profession. The other men who are included in the ranks of our leading Institutions and Societies are almost universally those with whom the dignity of the profession is quite safe, and the exceptions are so few in number that special legislation to curb their eccentricities is hardly worth the trouble of promotion; and further, by reason of the high standard of efficiency imposed upon the profession by the present requirements of the Institution of Civil Engineers, this class of man will soon become extinct. As regards the dignity of the profession therefore, it is apparent that the chief need is to prevent the unqualified men from pretending that they are members of it, as by so doing they lower the prestige of the whole in the eyes of those who cannot distinguish them from legitimate engineers. There is, however, another aspect of the case which strikes nearer home by touching the pockets, and that is unqualified men doing engineering work although such men do not necessarily pose as engineers. It must be remembered that the phrase engineering work covers a very wide range. If we take the definition given by the Institution of Civil Engineers, namely, that it consists of directing the great sources of power in nature for the use and convenience of man, we see that there is scarcely any work that is not

to some extent connected with the practice of engineering ; and while in some cases the highest possible degree of professional skill is requisite, in others a moderate amount of common sense would enable any man to carry out the work. The difficulty of legislating for such varied conditions is apparent, but until a scheme is evolved which will do so, very little real progress is likely to be effected.

MANAGEMENT OF SCIENTIFIC SOCIETIES.

The first point to be considered under this head is naturally the election of members. The usual course is for an applicant to fill in a form which is submitted to the Council and criticised ; after which the man is either approved for election or rejected. The result depends to a very large extent upon the skill displayed in filling up the form. It is a frequent occurrence for a young engineer after having served his articles and completed his preliminary training to accept a post as clerk of works or resident engineer, these terms being synonymous on small works. If in applying for election to a professional society he describes himself as a resident engineer he would probably find his path an easy one, but if by chance he said he was clerk of works his application would receive a much closer scrutiny and he would have to fight hard to prove that he was really an engineer and thus eligible for election. Then one frequently finds that a man is described as having been "engaged on" certain work. This may mean anything, and the writer can call to mind one case in which eight men separately received testimonials stating that they were "engaged on" one scheme. It is true that they were so engaged, but there was a considerable difference in the degree of responsibility, and the actual amount of work done individually varied from supreme responsibility and two years' continuous work in the case of one man to perhaps a total of one week's work on the part of a junior who occasionally checked calculations and made one or two tracings, and yet those testimonials are of equal face value to all the men and would also be of equal assistance in obtaining admission to a professional society. This could easily be obviated if in filling up the form a man was required to state the number of men engaged professionally with him upon the scheme referred to and his position relative to the others, and in the case of works upon which a large number of men were engaged where this rule could not easily be applied he should state very clearly what his duties were. Even when the greatest care is exercised undesirable men occasionally find admittance and will do so until candidates are personally interviewed and cross-examined before their application is approved. It would not be necessary for all to appear before the Council, but certain Members, distributed over the country, could be selected and formed into

local advisory committees, before the nearest of which each candidate could be directed to present himself. The reports of the Committees need not necessarily be binding, but they would be of considerable assistance to the Council in arriving at their decision.

Now as regards the Council, one-third of them are, in many societies, required to retire each year, but are eligible for re-election. This is a very wise provision as it more or less ensures continuity of policy in the governing body, but on the other hand when once a man is elected he serves for three years even though he may be found unsuitable or perhaps he may be too busy to give the required amount of time to the work of the Society. In either case his seat could be better occupied by someone else. Then again at the triennial election a good man may lose his seat, perhaps through the extreme popularity of new candidates, even though he may have served for many years and become one of the senior members. The writer suggests that in the first place Councillors should be elected for one year only so that they would require re-election each year but after they have been so elected for three years in succession they should then become permanent Councillors and remain as such, subject of course to death or voluntary retirement, until by rule of seniority they are automatically promoted to the post of Vice-President and ultimately President. Death, retirement and the probationary period of three years would allow sufficient opportunity for the introduction of new blood while the permanent members would exert a steadying influence upon the policy of the Council.

TRAINING OF CIVIL ENGINEERS.

The ramifications of engineering practice are so wide and developments are taking place at such a rapid rate that an engineer can never possibly reach that stage when he can say he has learnt all there is to be learnt of his profession. The training undergone by civil engineers can only therefore be considered as a preliminary course of work, which will not by any means teach them their profession but will develop their reasoning and deductive powers so that they can appreciate the relative value of, and assimilate, the lessons waiting to be learnt by them in after years. As an educational factor directing the course of young engineers the Institution of Civil Engineers has gained a high place, and although men may criticise they are forced to admit that the qualifications demanded by the Institution as a preliminary to election of Associate Members fix to a great extent the course of study which a young engineer must follow.

The routine followed by young engineers in learning their profession varies considerably in individual cases. This is an

advantage inasmuch as the men are not thereby all turned out from one mould to the same pattern. The various steps include a course at an engineering college or attendance at evening classes in a technical school, apprenticeship, and service as an assistant to a civil engineer. To be a competent engineer a man must possess a judicious mixture of theoretical and practical knowledge. The mere fact of passing an examination does not indicate that a man has all the theoretical knowledge that he will need. If he has worked under a coach for the examination it is probable that he will only have assimilated sufficient knowledge to satisfy the examiners, and much of it will be of a superficial character, so that he will most likely forget it all in a very short time, but if, on the other hand, he has followed a regular course of study over a protracted period he will have obtained such a thorough grounding in the subject that it will remain with him and be of service to him for the remainder of his life, and further, if during his training he has mastered the fundamental principles of his profession, he will be able to apply them and extend his theoretical knowledge to keep pace with his needs. A college course must, at least as regards Civil Engineering, be considered solely as an education in theoretical principles; the average graduate being hopelessly impractical when he first meets engineering realities in the office or on the works. So long as this is duly recognised it does not detract from the advantages gained by following a college course, among which the development of character and individuality is by no means the least important. If the man perseveres in his studies and obtains a degree it will probably be to his subsequent professional advantage. Now bearing in mind the dictum previously laid down, that an engineer should possess a judicious mixture of theoretical and practical knowledge, we have to decide whether this can be obtained by a man who, upon the completion of a college course, forthwith obtains an appointment as assistant to a civil engineer, or in the alternative, articled himself for a period of two or three years. As an assistant a man is paid to do certain work for the benefit of his employer and is expected to do that work expeditiously and in a practical way. His labours will, during the first three or four years, probably be limited to the preparation of detail drawings from rough sketches and other similar work which gives very little opportunity for the utilisation of theoretical knowledge, except in a very indirect sort of way. In fact an assistant is generally promptly subdued if he attempts to introduce theoretical ideas, because crude theory is of no use alone, and he does not know how far theory should be employed nor how to adapt it to practical purposes. It is only necessary to mention the frequently quoted example of the thickness of cast-iron water pipes for medium pressure, to emphasise this point and show the great

divergence in some cases between theory and practice. The general result is that the assistant quickly comes to the conclusion that theory is something specially devised as a species of torture which is only useful for answering examination questions, and when that purpose has been served it had better be forgotten as soon as possible, as, to his limited observation, the practice of engineering appears to consist of the application of rule-of-thumb methods. Taking a post as an assistant immediately after leaving college, the young engineer receives remuneration for his services at an early date, but although that may be an advantage at the time, it distinctly limits his capacity for development in the future, which is not only detrimental to him personally but prevents him from taking his part in the general advancement of the science of engineering.

There remains the alternative method of apprenticeship, or serving articles, to be considered. The articles usually provide that the master shall "teach and instruct the pupil in the practice or profession of a Civil Engineer." The design of engineering works is based, as the writer has already stated, on theory as well as practice, therefore it is the duty of the master to instruct the pupil or see that he is instructed in both directions, but it is to be feared that many engineers consider they have fully carried out their part of the agreement by permitting the pupil to sit in their office, see the practical work which is going on, and pick up what information he can without any assistance whatever. By this system the pupil is first charged with theory and then with practice, without at all understanding the dependency of one upon the other. His services are probably utilised in the work of the office in a similar way to that in which an assistant is employed, and in some cases, notably in municipal offices, pupils are foisted on to the engineer to do the work of, and save the salaries of assistants, while the public are led to think that because a man has served articles he is necessarily a trained man. From this it may be inferred that no engineer should take as pupil a boy straight from school unless he is not only prepared to teach him, but is capable of teaching him, the whole of the theory he requires and to show him how such theory is, or can be, utilised in practical work. If on the other hand the boy first attends a college course, then, when he comes into the office, he still requires to be shown how to make practical use of his theoretical education. This requires a large amount of theoretical knowledge as well as extensive practical experience on the part of the instructor, and it is by no means a universal rule that these two qualities are found together. It further involves a considerable amount of personal time being spent with the pupil and consequently it does not pay to take a pupil at the usual rate of premium, if he is to be properly instructed in the way he should go. Therefore a full explanation of what he

needs should be given to a prospective pupil and a fee fixed to correspond therewith ; if the figure suggested is too high for his means then the amount of instruction can be decreased within reasonable limits to meet his pocket so long as he is made to realise that this is being done. He should not be allowed to think that so long as he serves articles it is immaterial what he pays and where he goes. The writer is aware that this is rank heresy, and the last time he expressed his opinions thereon at a public meeting an eminent man who was present said he considered it was nonsense and that if he tried to teach his pupils they would walk out of the office. However, a pupil is not the best judge of the kind of training he requires, and the relative advantages of the two methods of training during apprenticeship can easily be seen by comparing the performances of two assistants of equal mental capacity but trained under the alternative ways. Before passing to describe a definite constructive policy for the training of civil engineers it will be well to consider out-door work for a moment, as there is no doubt that the experience which may be gained on works in progress is of the utmost value. It cannot be contended that after following a college course and say, one year in an office, a man is qualified to hold a responsible position upon works, therefore it follows that if a pupil is put on out-door work he can only have "the run of the works." He may possibly be employed to do a little levelling, and he can see what is going on, but the resident engineer or other man in charge will be far too fully occupied with his own duties to explain the why and wherefore of everything to the pupil, so that unless the latter is particularly sharp he will not learn very much. Then although if a man spends his time continuously on one job, there may be a little to be learnt each day, still, he could learn considerably more by only spending say one week on each of a large number of jobs, or in a big scheme one week on each part of it. It would also probably be of greater advantage if a considerable portion of the period allocated to out-door work were taken up in day or half-day visits of inspection in the company of the chief or a qualified assistant, able and willing to point out all that there was to be learnt at each place.

In concluding the remarks under this head the writer suggests the following general course of training as being most likely to produce competent engineers.

Upon leaving school the prospective engineer should, if financial considerations permit, spend three years at an engineering college followed by three years' apprenticeship under proper conditions. If he cannot see his way clear to do this he should, upon leaving school, article himself to an engineer for three years and concurrently attend evening classes in approved subjects. The homework in connection with such classes should

be done at the office under supervision, the difficulties explained away, and the application of the principles involved pointed out, using as far as possible for this purpose the practical work in hand in the office. It is useless passing on to the design of practical work until the theory is mastered, and therefore three years' articles are all too short when a college course is not taken in addition. As soon as possible the pupil should be put on practical work; if he has been to college this will be very soon after commencing his articles; but if not, he will probably be in his third year before it can be done; it being borne in mind that in either case he must be continually instructed in the reasons underlying all that he does. During his pupilage he should visit manufacturers' works to see how the various materials employed in construction are made, and he should visit works in progress to see how they are used. As it is to the engineer's advantage that his pupils should be a credit to him it is desirable to retain a non-college pupil for at least another year, even if it involves employing such pupil as an assistant and paying him a small salary for his services. At the end of this time he should be ready to be turned out, fully equipped with all the preliminary knowledge needful to help him to make his way in the profession of his choice.

QUALIFICATIONS OF ASSISTANTS.

It is not an unusual occurrence to hear engineers complain that they cannot obtain competent assistants; that is, assistants who have a good theoretical knowledge tempered by practical experience, and who possess a large amount of common sense. To these qualifications may be added a well developed sense of proportion so as to appreciate the relative degree of accuracy required in the works they are engaged upon; for instance, in setting out the levels for a sewer the same care need not be devoted to them for a gradient of 1 in 20 as for 1 in 2000. Then again a rough preliminary design may be required at a few hours' notice, in which case it is impracticable to give any consideration to details, although they may, and will be, of the greatest importance subsequently in preparing the complete design; but it is not given to every man to be equally successful in both classes of work. It will probably be said first, that there are many assistants who fulfil these conditions and, secondly, that the wretchedly poor remuneration generally paid does not offer any inducement for a man to seek to increase the value of his services after he has obtained a modicum of general knowledge. Possibly both these statements are correct, but as regards the former one, the difficulty experienced is that of finding the men. An advertisement brings perhaps hundreds of applications among which are doubtless some from men with exceptional qualifications, but there is considerable art displayed in the preparation

of the documents and the man who writes the best application will probably be the one selected, or perhaps it would be more accurate to say that, no matter how good a man may be, unless he can write an effective application he will stand very little chance of being selected. There are some men of wide experience whose attainments are such that they would prove successful in almost any undertaking, but in many cases such a man would be passed over in favour of one who has spent his whole life upon work similar to that in connection with which the vacancy occurs, although in the writer's opinion the best men are not those who have always kept within one narrow groove. The tendency therefore in writing applications is to suppress entirely or relegate to the background all experience which does not bear directly upon the case in point, as such a course has the effect of giving undue weight, and therefore the desired prominence, to the experience which is required for the post. The testimonials will of course be universally good, as the candidate would obviously only send those which would help his case, the others being omitted. There are at the present time, owing principally to the continued depression in trade, a large number of highly skilled men desiring to obtain suitable appointments, but as a general rule, when an engineer has secured an assistant who complies with his ideals, he will not part with that assistant except in case of direst necessity, knowing as he does the difficulty he will experience in finding a successor when, in due course, he desires to fill the vacancy.

Now the remuneration obtainable doubtless follows as a result of the working of the universal law of supply and demand. The supply at the present time is, as it has been for many years past, greatly in excess of the demand, and consequently the rate of pay is low. It must be admitted that the supply is of a very mixed character, and that if the undesirables could be eliminated the remuneration of the qualified men remaining would increase at once. There is, however, a limit, and a low one too, beyond which it is very improbable that salaries would go. A member of the present Government is reported to have stated some years ago that no man was worth more than £300 per annum, and although this statement has been freely commented upon and objected to by some people, the writer suggests that there is much truth in it if it is considered in the proper light. Men may be divided roughly into two main classes—workers and administrators. There are subdivisions which cover the men who are principally workers, but yet engage to a slight extent in administrative work, and those who conversely are principally administrators but yet engage in executive work. The expert witness and the experienced consultant, who are paid high fees merely for giving an opinion, may perhaps be considered as workers, but the steps by which they have risen to that high eminence separate

them entirely from the other vast army of workers, the assistants who carry out the instructions of the administrators in authority over them. The administrator devises schemes which may require the services of a large number of workers to carry into execution, and while his remuneration may reach a very high figure, if it is divided per capita among the instruments he employs, which are not necessarily confined to the assistants on his permanent staff, it will rarely be found to exceed a value of £300 per annum each. This cannot be taken as an average figure, because as each part of a machine is essential to the perfect working of the whole, so is each worker, however humble his position, an integral part of the machine working for the administrator. As a profit is required on each worker as well as on the whole, it is apparent that so long as a man remains a worker his remuneration cannot exceed the figure mentioned; therefore it is necessary that he should strive to join the ranks of the administrators if he desires to obtain a position of comparative affluence.

In large professional offices and industrial concerns it is obvious that there must be many men occupying sub-administrative posts under the chief administrator at the head of the concern, but in smaller offices the chief can probably do by himself all the administrative work required, and the worker has very little chance of rising. A good administrator may be, but not necessarily, a good engineer; he is primarily a first-class business man. We have notable examples of the combined qualifications in the case of Mr. J. C. Inglis, President of the Institution of Civil Engineers, who is General Manager of the Great Western Railway, and Mr. Donald A. Matheson, M.I.C.E., who was appointed General Manager of the Caledonian Railway in August last. The administrator must know where and how to get his work done, and when it is put before him he must consider it more from the point of view of its commercial possibilities than of its beauty as an engineering design. If a man is a highly skilled engineer he is tempted to produce designs which are perfect in all respects, and probably expensive to manufacture or construct, while a man who has far less engineering ability, but greater commercial instincts, will produce a design which, though inferior in technique, may be far more suitable from an economic aspect. As this is eminently a commercial age, the latter man will reap the greater reward, although it must be conceded the result will not conduce to the advancement of the science and practice of engineering in its highest sense. Those engineers who are in practice out of love for their profession may choose the course best suited to their taste, but the majority of men will prefer that which gives them the greatest return, and they are at the same time benefactors to mankind by bringing some of the advantages of engineering science within the reach of those with moderate means.

Mere professional skill in an assistant will rarely enable him to rise above the rank of worker. If he starts without or cannot acquire capital, his best course would appear to be either to join the public service in the municipal or other branch or to join a large industrial concern, and to stop in such office where his skill, or more probably his patience, will gain promotion for him from time to time. If he wishes, for any reason, to make a change, it should only be done after very careful consideration, and then only to a parallel concern. It is almost hopeless at the present time to rush into private practice, after acquiring the necessary preliminary experience, unless a man has a considerable amount of capital, so as either to buy a business or partnership, or to support himself while he is building up a connection, which takes many years to do. In the engineering world it seems that the men of to-day are at least ten years behind those of the last generation in the race of life, that is to say, that a man of forty to-day occupies a position comparable with that which a man of thirty would have held twenty years ago, and the change has come about so rapidly that the present generation have hardly had time to find their bearings. The next generation will not expect so much, and therefore will not experience to such an extent the serious discontent which is now apparent on all sides.

The writer attaches considerable weight to the difficulties in the way of a young engineer obtaining a just and adequate recognition of his capabilities, and with a view to inviting criticism and discussion, he puts forward the following scheme. A central bureau should be established, where a register would be kept of the career of every engineer. When starting in business the embryo engineer should apply to have his name entered upon the books, and a page in the register bearing a distinguishing number would be allotted to him; such number being henceforth known as his registered number. Upon the page would then be entered his name, date and place of birth, brief particulars of education, and an enumeration of his higher scholastic successes, if any, together with copy of a "leaving" certificate from school or college, and a note of the manner in which he is starting his professional career. That is to say, if he is serving articles the entry would give date of starting, period proposed, and name and address of master. Upon the completion of his articles a brief report upon the knowledge and experience gained should be supplied by the master to the bureau, where it would be entered in the register, and the original then sent to the apprentice. Similarly with appointments, a note should be made of the same at the time of entering upon them, and at the conclusion a certificate from the employer stating salary paid, scheme engaged upon, with description of work actually done in connection therewith, cost of schemes, and, what is most important, a very clear definition of the exact degree of responsibility borne by the

assistant should be added. From time to time any notable event, such as success at examinations, would be added, and at any time the record could be brought up to date without necessarily waiting for the termination of any particular appointment. In this way a clear, concise, unvarnished statement of a man's experience will be available for reference and testimonials will be rendered unnecessary. It is not necessary or even desirable that the entries should stop when the man ceases to hold a subordinate position, but particulars of notable work carried out by him could be added from time to time. The space devoted to each man would be strictly limited to one page, so that if he filled it with unimportant details he would probably find in later life that his doings would have to go unrecorded.

The register should be open for public inspection and should be considered as a public record from which certified extracts may be supplied on demand. When a vacancy for any post was advertised, instead of sending in an application as is now done, the candidate would simply write to the bureau asking that a certified copy of his page be sent to the prospective employer. Although any individual would have perfect liberty to make an independent application if he preferred, it would probably be much more to his advantage not to do so, but to rely upon his official record.

The money required to work the bureau could be obtained from fees if a sum of five guineas was charged for the preliminary registration and then a sum of say half a crown for each subsequent entry while a man was in a subordinate position and half a guinea per entry afterwards. A copy of the page should be made by request and sent out in connection with applications for appointments at say half a crown each time, while an inspection of any one page of the register should be allowed for the sum of one shilling, and a certified copy of any one page supplied on demand to the public for half a guinea. These fees would probably be sufficient to allow of classified lists of engineers and assistants being prepared, so that in the event of any employer applying to the bureau he could be supplied with a list of men suitable for his needs, whose records he could forthwith examine and make a selection of candidates for personal interview. Similarly, before entrusting work to an engineer or an assistant a prospective employer would as a matter of precaution obtain a copy of the man's record, if he had not previously been supplied with one, and unless a man had a good record he would find himself left on one side in favour of a man with a better one. In order to give an official tone to the register the bureau should be under the control of a strong body of engineers, and probably none better could be obtained than the proposed Association of Consulting Engineers, in the membership roll of which will probably be found the majority of the leading engineers of the country.

EXAMINATIONS.

Inasmuch as examinations have a very considerable influence upon the course of study followed by prospective candidates, the organisation and management of them is a matter of importance. The ability of a man to answer a few set questions, usually of a very unpractical nature, may prove that he has pursued certain theoretical studies and has a good memory, but they do not prove him to be an engineer. Theoretical examinations are very valuable during the time a man is obtaining his preliminary education, but after that they should be strictly banned and their place taken by more practical examinations devised to ascertain the extent of the candidate's practical experience and to prove his competency to carry out the duties appertaining to that branch of the profession in which he is interested. It should, however, be borne in mind that practical experience alone is of very little value unless accompanied by theoretical knowledge, therefore the examination must be directed to both ends, but greater prominence should be given to the practical part than the theoretical. The wide scope of engineering and the varied experience of the candidates render it a difficult matter to prepare a scheme of examinations in practical work which will be equally fair to all, but this difficulty does not occur with regard to the theoretical part, as that is more or less common to all branches.

The most recently devised syllabus relating to engineering examinations is that issued in the early part of this year by the Institution of Municipal Engineers. It is decidedly "advanced" and probably embodies the most modern ideas on the subject of examinations; whatever its merits or demerits there is at least no other examination held under like conditions. The general idea is that the papers shall be of as a practical nature as possible, but every candidate must show a satisfactory knowledge of the fundamental principles underlying the practice of his profession, the details of administration and the various legal enactments affecting his work. In addition to the questions being practical ones, it is also sought to reproduce, as far as possible, the conditions under which the candidate works in his own office. To this end he is allowed to use in the examination room any text-books approved by the Examination Board, so that practically he could take his whole library if he wished. This is a startling innovation, but it is practical. If a man knows his business, he knows his reference books and where to lay his hand on any information he may require, so that the book will be of considerable use and allow him to sit for the examination without having previously to learn by heart innumerable formulæ and other matters. If the man does not know his business he will probably spend the bulk of the time allotted to

answering the questions in searching through his books and will have very little to show as a result of his work.

As regards the examination itself, the first part consists of a general paper which is compulsory on all candidates and deals with general practice and the theoretical principles involved therein. The second part comprises special papers in the principal branches of Municipal Engineering, but it is recognised that a man may be a very efficient highway surveyor without having experience in structural work, or say a good waterworks engineer without knowing anything about sewerage, therefore certificates are issued for competency in each or any of the special subjects, provided the candidate also satisfies the examiners in the general paper and in a *viva voce* examination in each of the subjects he takes in the written examination. A diploma in Municipal Engineering is issued to candidates who pass in three special papers in addition to the general paper.

Although the examination has been promoted by the Institution of Municipal Engineers it is a public one in every way, and the passing of it is not made a condition precedent to membership of that Institution.

The control and conduct of the examination has been placed by the Council of the Institution in the hands of an independent Examination Board which, it is interesting to note, includes five Fellows or Members of this Society. In order that each candidate shall be treated with scrupulous fairness he is questioned and his written papers are examined by two examiners, who make their respective recommendations to the superintending examiner. The superintending examiner then personally examines each written paper and forms his opinion thereon, after which he considers the reports made by each of the other examiners and decides as to the propriety of granting a certificate or diploma to the candidate. If there is any serious difference of opinion between the several examiners, which cannot be adjusted, the matter is referred to the Board for a final decision.

CONCLUSION.

Although there are many other topics of professional interest which might have been referred to, the writer suggests that those he has brought forward are amply sufficient to form the basis of a discussion within the limited time allowed and that consideration of the others may be deferred to a later occasion.

DISCUSSION.

The **President**, in moving a vote of thanks to the author, said that they were very much indebted to him for the paper on account of the variety of important questions which had been referred to. The engineering profession certainly involved

a large number of issues. They were all very glad to hear that the status of the profession was now receiving a good deal of attention, and that the requirements of the Institution of Civil Engineers had been so much raised that the efficiency of its members would be considerably increased. The author laid great stress in his paper on the practical side of the question, and the experience which could only be obtained on actual work, and he (the President) quite agreed with him. He (the President) was, for some years, a contractor's engineer on one of the heaviest railways in England, and the experience that he there obtained had been invaluable.

The author referred to the desirability of the prospective engineer spending three years at an engineering college. He (the President) quite agreed with that view, and he certainly thought that men who were about to enter the engineering profession ought to be prepared to provide for the necessary expenditure. Gentlemen entering the medical profession or the legal profession knew that they would have to spend a considerable sum of money; and he thought that a fair amount of money ought to be spent in the training of an engineer if he desired eventually to obtain a good position. A good many men throw away their chances of getting on in the profession by entering a drafting office at a small salary when they were out of their articles, instead of continuing with their training.

The vote of thanks was unanimously agreed to.

Professor R. H. Smith said that the paper contained a great many useful suggestions. He had spent a good deal of his life in trying to persuade students of engineering to believe that college training alone was not sufficient to enable a young engineer to take a position of the slightest responsibility in the practice of engineering. It must be supplemented by several years' practical work upon works and in the workshop, or in outdoor work, under suitable skilled direction.

He thought that the idea of an authentic register of the training and professional practice of an engineer was very good, and he should like to see it carried out in a thorough-going fashion. He did not think that mere membership in any of the great engineering institutions was an infallible guarantee that the member was a good or even a reliable engineer. Examinations were now used in qualifying for grades of membership in the engineering institutions; but he knew very well that the examiners who set the pass examination papers for the engineering institutions were not allowed to do their best in setting the questions. They were not allowed to set questions which, in the opinion of the Board of Examiners, could not be easily answered by the bulk of the young men who had undergone the ordinary training which was available at present. Possibly the Board

of Examiners was justified in that respect. They thought that it was not fair to set questions which the average text-book training would not enable the candidates to answer. But the papers ought to include questions which were directed towards practical work and the exercise of practical common sense, whether the existing text-books did or did not deal with them. Unfortunately, text books were written with almost the sole purpose of passing students through examinations, and if the examiners in their questions did not lead the way to better things, the text-books would not follow.

The author had referred to a special kind of examination which had been introduced this year by the Institution of Municipal Engineers, in which the candidates were allowed to bring books with them to the examination. That was spoken of in the paper as an innovation, but it was not really so, for he had himself during the whole of his engineering teaching, which extended over nineteen years, allowed students to bring any books they chose to all examinations except those for junior students. He had learned this system from Professor Fleming Jenkin, at the Edinburgh University, who, as early as 1870, allowed the candidates to do this. It was very noticeable that those who brought a big pile of books did not do any good, and that those who brought in only three or four which they knew thoroughly were the successful students. To most students a large number of books would simply be an encumbrance. The teacher ought to warn his pupils against burdening themselves with books with which they were not acquainted.

He thought that the register which had been proposed would be very useful under certain conditions, one of which was that all the entries should be absolutely guaranteed to be perfectly impartial and just. The writers of the reports which were to be entered in the register ought to be sworn to make the reports impartial and just. A register compiled under some very strict guarantee as to its accuracy would be of immense good to the employers of the country.

Mr. J. W. Wilson said that the author had laid down some very excellent rules with regard to the training of engineers; and, if they could be followed out properly, we should be very much nearer to a solution of the vexed question of how engineers should be trained than we are at the present time. Life was short, and it was very uncertain; therefore, although, theoretically, an engineer ought to know "something of everything," there was not enough time for this purpose; and the real problem was how to lay out to the best advantage the few years of the early part of a man's career, when he was, perhaps, most susceptible to the influences of education.

The paper contained some very important points. For

instance, the author said, "To be a competent engineer a man must possess a judicious mixture of theoretical and practical knowledge. The mere fact of passing an examination does not indicate that a man has all the theoretical knowledge that he will need." This was perfectly true. There were some men in the profession who were only practical and not theoretical. And there were others who, unfortunately, though very highly theoretical, were not practical. Neither practice nor theory by itself was of very much use, although the practical man without the theory was, perhaps the better of the two ; or, at any rate, of more use. If they could manage intimately to combine theory and practice they would be doing the right thing ; and certainly the mere fact of passing an examination, as examinations generally went at the present time, was very little proof that this combination had been effected.

The author spoke repeatedly of the necessity of teaching the young engineer the reasons of things. That was an excellent proposition ; but he was doubtful whether every pupil in an engineer's office or in works was placed in such favourable conditions that it could be carried out.

The author had referred to the development of the student's character as being one of the advantages of a college course, and that was a very important point. It involved the proposition that, as no two men are alike, each engineering student was to be trained, as one might put it, "on his merits." This meant that a professor must have a limited number to train. If he was to have fifty or sixty men in his department, what was suggested could not be done. The result would be "training in a groove." In such cases all would be worked out more or less to the same pattern, and the results would often be disastrous.

If it was thought that any written examination alone would prove the desirability or otherwise of an engineer being admitted into an engineering society or institution, that view was, to a large extent, a fallacy. Examinations were, however, certainly good in the direction which was indicated in the close of the paper. There must be some means of ascertaining what was the practical experience of the candidate ; and he believed that that could be very largely ascertained in a *viva voce* examination. Of course, that would involve a great deal of time, but unless an examination was conducted in some such way it was, in his opinion, no true examination at all. Any such form of examination, however good it might be, was only part of the story. It was absolutely necessary that when an engineering student received a certificate or diploma, he should receive it not only because he had passed an examination well, but also on account of his ability in his daily work, his punctuality, his conduct, his zealous integrity of purpose, and all such matters. If that was done, they would find out who were the really good

men, and they would be able at examinations to eliminate the desperately brilliant, clever, and sharp men, who, if only tested thus, though considered to be the best, would be found afterwards to be among the worst. He cordially supported what the Institution of Civil Engineers had lately done in making sure that a man who wished to be a civil engineer should have, at any rate, a minimum of five years' training. He regretted that the Institution had not emphasized more the importance of actual practical shop training for a civil engineer, but they said quite rightly that their examinations were only a portion of what was necessary for election to corporate membership in their body. As regards the amount of theory which was required, it was possible to go too far. In the introduction of one of the best known engineering pocket-books it was stated that the mere fact of a man being capable of absorbing the highest branches of theory was a proof in itself that he would never be an engineer of practical use. Engineers ought to teach their students so that the rising generation might, if possible, become better engineers than the present generation, and they must be taught a sufficient amount of theory, but it was equally necessary to give them a sufficient amount of practical experience. The two things must not be severed. In his opinion it was not going far enough to say "six months' theory and six months' practical work alternately." The two things must be combined thoroughly throughout. He was glad to see that the author mentioned the personal training of the student, for, after all, the formation of the character of the young man was as important as any other part of his training.

Mr. P. G. Scott said that although the paper dealt only partly with the subject of the status of the engineering profession, yet it treated of many matters of present-day interest to engineers. Now was the time that every effort should be made to study the subject carefully from its various aspects, and, as they knew, this was being done in various ways by several engineering societies, including their own. The present period might be described as the diagnosing period, but the author seemed to think that remedial measures should apply only to those whom he had designated as "administrators." In the speaker's opinion, however, the complaint affected the whole body of the profession, even down to the humble workers.

Regarding the election of members of council, he should be inclined to extend the probationary period to five years, as with the three-year period there was likely to be a block in the elections for some time, and electors were liable to be deprived of their privilege of voting during that period. Whatever the principle of election was, the privileges of the voters should not be minimised.

The paper fixed a wide gulf between the consultant and the non-consultant classes of engineers, or "administrators and workers," as they were designated by the author. There were, he ventured to say, a large number of engineers who were not consultants, but yet occupied high positions as engineers at salaries commensurate with those positions, and of whom a considerable amount of administrative as well as professional ability was required. There would not be much inducement for men to go in for an expensive training if they knew that their remuneration was likely to be limited to £300 a year. They would go into more paying fields of labour, and the engineering profession would be left with inferior men in the non-consulting class of engineers. What was required was, in his opinion, the improvement of the profession as a whole, both as regards consultants and non-consultants, as every engineer had not the opportunity or the means to become a consultant, although he might be well qualified to do so. As a matter of fact, a great number of consultants of the present day had, while they were "workers," acquired a considerable degree of eminence in their profession before setting up in private practice. *Esprit de corps* was greatly needed in the profession; the business of the various classes of engineers should be defined; and non-qualified men should be prevented from acting as engineers.

As regarded the register of engineers, there should be, he thought, an Engineering Directory compiled on the same lines as the Medical Directory. Young engineers and those who were not well known to the public should refer to the various engineering societies to which they belonged, such societies keeping registers on the lines suggested by the author. There should be inter-relation of the various engineering bodies or societies and not a monopoly of power by one body.

Mr. Percy Griffith said that this subject had been before the members in a very special way lately because premiums or prizes had been offered for essays dealing with it. He very much welcomed the present contribution in the form of an ordinary paper, because he hoped very soon to see the author a member of the Council, and so outside the ranks of competitors for premiums.

He was sure that they had all followed the paper with great interest and in admiration of the author. When the author became a member of the Council he would have personal experience of many of the difficulties to which he had referred, and the opinions which he had formed with regard to various details, such as that of dealing with candidates for admission to societies, would be confirmed. With regard to this Society, the author would find that they had gone a long way in the direction he had indicated in his paper in regard to the examination of candidates for admission to the class of Fellows. They had realised the

difficulty of dealing with those professional men who claimed some higher degree of competency than that of an assistant, and an attempt had been made to find some means by which the ability of candidates to deal with matters of design and practice might be tested. That course had been adopted by the new Institution of Municipal Engineers.

He did not agree with what Mr. Wilson had said as to confining the test to a *viva voce* examination. He thought that papers might be set so as to give a very intelligent and intelligible idea as to a professional man's ability to advise clients in carrying out a particular class of work. This was very much more easy now than formerly because the professional world had become specialised to such an extent that now it was rare to find a consulting engineer practising in more than one or two branches of the profession.

The most practical and interesting suggestion which had been made by the author was that of the register. If such a register was instituted universally, technical engineering institutions would lose a very considerable amount of their *raison d'être*, and they would perhaps fall back upon their original intention and confine themselves to discussing particular branches of engineering. It was very difficult to make up one's mind as to whether the register would be better than the methods which were now in use by the different engineering institutions.

It must be confessed that the author's proposal was novel and ingenious, and that it tackled a difficult matter in a very plucky way. Many of the details of the proposals might be criticized, but he would only mention the suggestion that engineers were to have numbers like convicts, and be denied the honour of having their names associated with the record in the register. He also did not like the idea of limiting a man to one page. The author did not say what size the page was to be. He would like a little scope left for later entries, in fact, one often heard of very distinguished elderly engineers carrying out wonderful works, and it seemed desirable that they should have such things registered if they wished. At all events, as such records might be useful for obituary notices, they should certainly be open to addition up to the last.

One speaker had suggested that the author had dealt with the matter rather from the point of view of the consultants than of the workers, but in his (Mr. Griffith's) opinion the author had not dealt very completely with the question of that delicate creature, the consulting engineer. Being one of that class himself, he fancied himself using the register on his possible clients, and he could not quite see how it would work. He could not imagine a client, who might be debating as to which engineer he should call in, taking the trouble to go through the register, especially if the particulars of each one extended to more than

one page, as he (Mr. Griffith) hoped they would. He was a little afraid that the consultant would hardly obtain the notice which he might reasonably expect if that method was to be adopted. If the scheme was to be further discussed he would ask that some better provision should be made for the consultant getting his merits known.

The author had practically admitted that his paper had been called for by something being wrong, and, towards the end of the paper, he suggested the register as the remedy. He was not quite sure that the author had fully appreciated the nature of the complaint, and he was bound to suggest that others who had dealt with the subject recently had hardly been able to diagnose the disease very accurately. He thought that one of the primary difficulties at the present time was scarcity of employment. The author had certainly referred to the fact of there being more men available than there was work for, and pointed out that this meant low remuneration. The profession was not now adequately remunerated in view of the expense incurred in preparation for it. One point in connection with this question was that there was over-specialisation. In the early days of engineering the same men undertook work both large and small, and from dealing with one element of nature in one case passed on to deal with another with equal facility, and their names were indelibly recorded on the page of history. Nowadays a man's opportunity was limited to one branch of the profession, and, if he had not been employed in more than one particular branch of the profession, his obtaining employment in any other branch was out of the question. That, he thought, constituted a very serious limitation of the opportunities of engineers at the present day.

Perhaps the most difficult point that they had to face was that engineering had been for the last thirty years considered a fashionable profession. To make a boy an engineer was to make him a gentleman, whether he was one before or not. Engineering was classed among the "honourable professions," and boys were made engineers, not because they showed any taste for the profession, but because their mothers were anxious that they should distinguish themselves. When boys were made engineers for no better reason than that, it followed that the profession would be overcrowded. Another regrettable fact was that it had become only too common to appoint young men as municipal engineers, at any rate in the case of the smaller towns, almost regardless of their ability to carry out the work which would be required of them. They might be able to deal with the more simple part of their work, such as road and sewer maintenance, but sometimes such men were called upon to carry out such things as gasworks and waterworks. They did their best, but heaven only knew how they got through without serious failures. The nature of the examination instituted by the new

Institution of Municipal Engineers was an admission that there were difficulties in that direction.

With regard to the remedy, he thought that it would have to be considered on much more simple grounds than the elaboration of the qualifications of engineers. The profession would, he thought, be in an unsatisfactory state until one of two things was brought about—either an increase in the amount of engineering work to be carried out, or else a decrease in the number of candidates who were competing to carry it out. He was on delicate ground, because he was speaking in the presence of professors who conducted engineering colleges, but he spoke from experience. Taking the colleges as a whole, they were turning out into the profession such an enormous number of men that, if the actual figures could be produced, it would be obvious that the supply was greater than any possible demand, and that, before the status of the profession could be improved, there must be something done to limit the number of boys turned into the engineering market to make a living as best they could.

With regard to the increase of engineering work, that was a matter of political economy, and he would not bring it into the discussion ; but he hoped that something would be done before long to develop the engineering resources of this country and its many Colonies.

Professor R. H. Smith said that he should like to correct a misapprehension under which the last speaker had spoken with regard to one point. Under present conditions it was not to the interest of professors at engineering colleges to have a large number of students. It was almost always the rule for the salary of the professor to be a fixed one, independently of the number of students. And, long before that rule became common, it was to the disadvantage of the professor to have a large senior class, because the trouble was far greater than any compensation he received in the way of extra fees. He could assure the meeting that he had been constantly engaged in persuading students not suited to higher scientific work and their friends that they ought not to go on beyond two years at college ; but the number of years best spent at college must, of course, depend upon the age and preparation at entrance, and also upon the equipment of the college.

Mr. W. C. Easdale said that the author had omitted in his paper to deal with one class of young engineers, namely, the engineer who had taken his college course and his degree in engineering, but who lacked both the experience necessary to gain a position as assistant and the means to apprentice himself to a civil engineer. He (the speaker) had heard that day of a case in which the parents of a man had, at great sacrifice, carried him

on through his technical education to the end of his degree course, but, at the present moment, they were unable to do anything more for him except, perhaps, to keep him for a year or two ; he had not sufficient experience for the position of assistant, nor means to pay for apprenticeship. It had been suggested to him by a friend that perhaps something might be done to try to get large employers, such as railway companies or large contractors and manufacturers, to take some of the best of these young students into their works free. Some of them possibly would become very good engineers, and they would have the opportunity of gaining experience, while the employers could select the best that came from the colleges.

Mr. E. H. G. Brewster said that, in connection with the register which had been mentioned by Mr. Adams, a good deal had been said about the rather fulsome reports which were often given by employers to men leaving their service. There was another objection to the register, which was the possibility that an employer and an employee might disagree, and then the servant might get an unfair report, and one detrimental to his character, put upon the register. He did not think that the register would be a workable scheme, or that it would meet with the approbation of either the employer or the employee.

The training of engineers was a subject which had been before the profession for many years. It had been before the Institution of Civil Engineers and the Institution of Mechanical Engineers. It had been considered very largely by the councils, and papers had been read upon it. A discussion took place at the Institution of Mechanical Engineers in which Mr. Yarrow, of torpedo-boat fame, advocated that pupils should have six months' training at college during the winter, and six months in works in the summer, and stated that he was carrying out that idea in his own works, and had been doing so for some time with the utmost success. This was a combination of science and practice. As had already been stated, the merely theoretical man was a very poor tool, while the merely practical man was only slightly better.

With regard to examinations, many men who were very good at written examinations were exceedingly bad at *viva voce*. They were nervous and timid when they came to be questioned in that way, but when left to themselves they could answer questions admirably. He thought that the scheme put forward by the Institution of Municipal Engineers was, taking all things into consideration, a very admirable one.

With regard to assistants, Mr. Adams had said that it was not an unusual occurrence for engineers to complain that they could not obtain competent assistants. He remembered one assistant who was found fault with because he did not know

something which his chief knew (he was an exceedingly able assistant who afterwards became a very good consultant when he had gained some experience). He turned round on his employer, and said, "Sir, if I knew as much as you do I should want £1,500 a year at the least. You cannot expect me to know all that you do." The assistant was between twenty and thirty years of age and the employer was between fifty and sixty. As one went on in years one increased in knowledge and experience : assistants were usually young men.

Mr. T. E. Bower said that, with regard to the register of engineers, if they had a record of a man who had been engaged on waterworks, such a man would not be put on to sewerage, tramway or railway works, but would be known only as a waterworks engineer. He would then have great difficulty in obtaining practical knowledge of other works than those he first came out upon.

In connection with night schools, which Mr. Adams had suggested, he might say that he himself commenced his practical career on waterworks on the moors about sixteen miles from a night school, so that his education could not be continued under tuition, and he did not know how a young engineer placed in such a position could do otherwise than continue his studies privately ; and the same difficulty would also arise in the case of most engineers engaged on works in the country.

Mr. Maurice Wilson said he thought Mr. Adams' paper was an excellent one, but that he wished the author had gone a little further back in connection with the training of engineers. He spoke about the training beginning when boys left school, but he (Mr. Wilson) thought that the training of an engineer ought to begin some time before that. A father, even if he was not an engineer himself, could find out pretty well whether a boy was likely to be a success as an engineer. If he thought that he was, he should place the boy at a school where he could be trained for entering the profession, so that when he left school he would be well equipped to begin at once his real engineering education. One of his (Mr. Wilson's) experiences in training engineers, which he had been doing for some twenty-eight years, was the difficulty of making the students exercise common sense. He found that the majority of students had very little common sense, and had seldom been taught to think at all. He had frequently seen the eyes of a student brighten when he had made him realise for the first time the object of a formula. It was important that when a boy left school the father should be prepared to spend the necessary time and money in having his son trained, not in one branch, but in the general foundations of engineering.

As the author had truly said, "the pupil was not the best judge of the training which he required," and if he began with the idea that he was going to be, say, a civil engineer, his professor might be teaching him things which were of great importance, but which the pupil did not regard as necessary, and therefore did not realise the great need of studying. He could remember the case of a student who, when he left school, went as pupil to an engineer whose speciality was the making of groynes. He learnt some levelling and surveying, as well as a certain amount of drawing, and, of course, the making of groynes. When his time was up he found that there were very few who wanted groynes made. The young man had only one string to his bow. He should have specialised after he had been trained as thoroughly as possible in general principles. It was a mystery how any parent with the present-day facilities for learning the profession could think of sending his unfortunate son straight from school to engineering works, where he was under a foreman who might be a very good instructor or might not, but where the principal object of the works was not to train students but to make the works pay. In such a case the pupil was bound to suffer.

In reference to a remark made by Mr. Griffith, he (Mr. Wilson) would like to say that at the establishment with which he was connected the object was not to try to turn out as many engineers as possible to flood the world. If a student proved unsuitable, great care was taken to inform his father at an early date, so that he might not spend money upon him and afterwards find that it had been wasted. Of course, as in all such establishments, there must be some unsuitable students. He remembered a gentleman saying, "I want to make an engineer of my son. We have tried him for the Church, and he is no good for that; we have tried him for the Law and Medicine without success; and now, as a last desperate hope, we are going to make him an engineer!"

Mr. Arthur Rigg wrote :—

As the present paper refers in no small degree to the practical and theoretical education of consulting engineers, and as there are now many schools where such education can be obtained, I think it will be of some interest to our members if I were to give an outline of some of the early work in this direction. I do this because my father first started an engineering school at Chester about the year 1842, and continued his work until 1869, after which the above school was closed. In the first number, and on the first page, and first advertisement in *Engineering* you will find a notice of his return to work, comprising practical and theoretical matters taught at the Chester College, which was an institution ranking with others of a similar character, though of a more recent date.

In the beginnings of practical work, in about the year 1842, much advantage was taken of the knowledge the students possessed of ordinary trades, such as carpentry, smith's work, etc., and (later on) I became a sort of foreman in carrying out my father's designs, and we made a steam engine, which was used for driving the pumps that supplied delicious water for the use of the college. As to the character of work carried on in those earlier days, if we did not aspire to higher things, at any rate we kept the practical side of engineering always in view. In those early days I well remember that there were no millionaires to supply funds for educational purposes, but the want was remedied in some degree by Sir Henry Cole and the Science and Art Department, South Kensington.

On the subject of classical as against mechanical education, I would like to say a few words in favour of classical education not being entirely abolished. In mechanical systems you enjoy a contact with laws that never change, but in contact with human beings you have to remember and take note of laws which are uncertain in their operation. In business transactions the one may be relied upon, but the other can never be trusted, and in business transactions it is of far greater importance to beware of a sulky bully like Achilles and to trust the type of a true gentleman like Hector.

REPLY.

Mr. H. C. Adams, in replying to the discussion, said that he very much appreciated the cordial way in which the meeting had received his paper, but there were not many points to be replied to.

He was very pleased that examinations had been touched upon. Professor Smith had said that in certain technical examinations the examiners were only allowed to set questions the answers to which could be got from the text-books. He (Mr. Adams) had a very large collection of examination questions, among which were many that he did not think could be answered from the text-books or by anybody else; and it was not at all clear what answers were really expected by the examiners. Examination questions were certainly better now than they were some years ago.

His reference to administrators and workers had been quite misunderstood by Mr. Scott. In speaking of administrators he had not consulting engineers in his mind at all; he divided engineers up between those men who did what they were told and those people who told others what to do. If a man was a junior assistant or an assistant without authority or control over others, he called him a worker; but when the man was placed in charge of an office and had assistants under him he then became what he (Mr. Adams) called an administrator. The ordinary assistant who

went into a small office and stopped there, and whose salary remained at a low figure, could not understand the reason for his non-advancement. It was simply because there was no scope for him there.

One objection had been raised to the proposed numbering of the entries in the register, but he thought that if the gentleman went to Somerset House and looked up the registration of his birth he would find that he was already numbered.

Then it had been said that this scheme promised well for assistants, but not for consultants; but he thought that if a scheme of this sort was carried out, second-rate assistants would very soon get squeezed out, and only those who were really good would come to the front, which would mean less assistants joining the ranks of the consulting engineers, and, therefore, more work per head.

He had not attempted to diagnose the cause of the present state of unrest in the profession. He had left that on one side, and he had only tried to deal, as far as he could, with a few specific points, because the whole matter was a comprehensive one, and he did not feel inclined to take it up now and bring it forward in the form of a paper.

The suggestion had been made that the railway companies should take college men free and give them practical training. But the engineers on the railways had on the list a good many pupils of their own who wanted to make a career, and, as there was no opening on the line for many of them now, they would not welcome the college men joining them.

He recognised the fact that the register would be of no use at all unless the statements it contained were perfectly straightforward. He did not suggest that the employers should give testimonials but certificates. What was wanted was simply particulars of the works in which the students had been engaged. The very object of a register of that sort was to prevent a man jumping about from one branch of engineering to another. The difficulty of doing that was brought up as one of the disadvantages of the register; but the trouble was that a man was brought up in one branch, and might know his work in that branch very well, and then try to enter some other branch. That was not good for the profession.

Mr. Bower had referred to the difficulty of a man who started his career on a railway or waterworks getting theoretical training. There was a very great difficulty about that, and he (Mr. Adams) did not think that a man ought to start his career on works of that sort. He, first of all, wanted preliminary training at a college. If he started on outdoor work he was not capable of learning the lessons which were put before him.

November 7th, 1910.

DIOGO A. SYMONS, PRESIDENT,
IN THE CHAIR.

PUBLIC SLAUGHTER-HOUSES.

By S. M. DODINGTON.
[MEMBER.]

THE time has arrived for engineers in this country to study seriously the question of public slaughter-houses, their planning, building, equipment and general organization, together with the best and most humane methods of killing animals, and the cleanest and most efficient way of dealing with dead meat and live stock. The question to-day as it affects the United Kingdom is how much longer shall we as a nation be content to lag behind every other civilized country in a matter that is vital to public health, practical economy and humanity?

Animals have to be killed for food ; it is therefore essential that they shall be killed in a painless way, under the cleanest possible conditions, and that no meat shall be sold for human food that is not absolutely sound and free from disease. To get these conditions, slaughtering must be centralised in public slaughter-houses where all killing and meat inspection is under the charge of veterinary surgeons and where all the by-products of the butcher's trade are collected and dealt with according to their nature. As long as butchers are permitted to kill animals in private slaughter-houses no reform can be accomplished, for it is impossible to inspect all the animals that are killed (very often under revolting and cruel conditions) in private slaughter-houses.

HISTORY OF THE PUBLIC SLAUGHTER-HOUSE.

The first public slaughter-houses we hear of existed in Rome in the Emperor Nero's time. The butchers were not permitted to kill privately but had to bring their animals to the public slaughter-house in the Forum, called the *Macellum Magnum*. There the animals were slaughtered and the meat was not allowed to leave the market until it had been passed by inspectors. As Rome decayed, the sanitary laws became slack, and butchers began killing in their shops and in the street, and it was not until the early part of the eighteenth century that the authorities took a strong hand, closed all the private slaughter-houses in Rome, forbade all private killing, and erected a public slaughter-house.

Even in the thirteenth century there were a number of public slaughter-houses throughout Europe. France and Germany had quite a number of towns which possessed public slaughter-houses, and no killing was permitted in these towns except at the public slaughter-house.

CITY OF PARIS IN DAYS GONE BY.

Until the beginning of the eighteenth century the slaughter-house system in Paris was terrible. Hundreds of private slaughter-houses, breeding dirt and disease, existed in crowded areas throughout the city. These private slaughter-houses generally discharged their offal and blood into the streets, and the filth of Paris was a by-word ; frantic animals, over-driven and tired, were brutally driven from the surrounding country into the city, through the streets, to the danger of all concerned, to meet their end in some dark den situated behind a butcher's shop. At last the inhabitants would stand it no longer, and in the beginning of the nineteenth century Napoleon built four magnificent public slaughter-houses for Paris, which stood for years as a model for the world. These public slaughter-houses were called " abattoirs " from the French word *abattre* (to knock down) and the word " abattoir " is now used in England to-day to signify a public slaughter-house.

PARIS IN THE EIGHTEENTH CENTURY.

As soon as the abattoirs were built in Paris, all private slaughter-houses were closed ; the chief Parisian abattoir was combined with the cattle market, animals were no longer allowed to be driven through the streets but had to be carried in conveyances ; all slaughtering was centralized as well as all the business connected with it ; no meat was allowed to leave the abattoirs until certified as sound by an inspector, and the nuisance of the private slaughter-house, together with the danger of unsound meat, was gone for ever. Paris to-day contains two splendid public slaughter-houses ; one at La Villette, which with the cattle market occupies about 175 acres, and another at La Vaugirard.

OTHER NATIONS FOLLOW.

Paris set the example and by the end of the nineteenth century every country in Europe, *with the exception of ENGLAND and TURKEY*, had abolished private slaughter-houses in large towns and erected public abattoirs instead. Nowadays on the Continent nearly every town over 5,000 inhabitants has a public slaughter-house ; in Switzerland even the smallest communities will not tolerate private slaughter-houses, but insist on having a public abattoir where all the meat can be killed under inspection.

On the Continent we generally find the abattoir is one of the finest buildings in the town and splendidly run in every way ;

it is invariably connected with the cattle market, and local railways ; animals are not allowed to be driven through the streets, suburbs, or even the rural districts immediately adjoining the town.

ENGLISH METHODS A FARCE : A NATIONAL DISGRACE AND
UNWORTHY THE NAME OF "SYSTEM."

There is no system whatever of meat inspection and slaughter-house organisation in the United Kingdom ; and we as a nation quietly sit down and allow ourselves to be shamed over this matter by every country in the world except Turkey and a few parts of the globe inhabited by savages. There is no law in England compelling public abattoirs in every town as in other countries, and consequently our great cities like London, Leeds, Sheffield, Newcastle, Birmingham, etc., literally teem with private slaughter-houses ; no systematic check can possibly be exercised over the meat supply, as the killing goes on at all times of the day and night in these horrible places, and frequently with unnecessary cruelty. A few men called meat inspectors (but who in fact know very little of meat inspection) walk round the butchers' shops and condemn some of the meat.

Many English towns have adopted public abattoirs ; but as the law cannot compel the closing of private slaughter-houses, we find the public abattoir used by only a few butchers ; the remaining butchers kill in their own private slaughter-houses, very often within a stone's throw of the public abattoir. The consequence is that a public abattoir does not pay, because all the butchers do not use it ; and it is therefore impossible to have a trained official in charge, and the institution becomes a farce. The public abattoirs in this country are, at the best, such poor affairs that we will only indicate their bad points and what to avoid in the future. The only town in the kingdom which has anything worthy the name of abattoir is Edinburgh.

ESSENTIAL POINTS.

When a town is considering the building of an abattoir, steps should be taken to secure an Act of Parliament to compel all butchers to kill in the abattoir and to close their private slaughter-houses as soon as the abattoir is ready for use. The abattoir should be large enough to allow all the butchers in the town, suburbs, and immediate rural districts to kill at the same time if necessary, and one of the most important provisions is that the grounds on which the abattoir is built should be large enough to allow of the extension of the buildings, so that additions can be made as the town grows and the population increases.

In order to prevent the use of private slaughter-houses just outside the town it is necessary to have as much control as possible over the country adjoining the town and to ensure that

meat coming from the country to the town will go to the abattoir for inspection before it can be sold in the town. Another point, perhaps one of the most important of all, is that the abattoir should be *combined with the cattle market*. Not only should all animals that are killed for human food be slaughtered in the abattoir, but there should be a special department attached to the abattoir for killing horses, donkeys, stray dogs and cats. By this means not only are ordinary private slaughter-houses suppressed, but knacker's yards with all their objections cease to exist, slaughtering is centralised, the by-products made good use of, and humanity enforced in a well organised public building. All this has been going on for so many years abroad that it is simply astounding that the question has not been tackled in a businesslike way in England.

ABATTOIR SYSTEMS IN VARIOUS COUNTRIES.

The writer has made a study of public slaughter-houses and humane slaughtering for a long period and has visited public slaughter-houses in nearly every country in Europe, as well as in South America, Egypt, the Far East and one or two odd corners of the world. In all the Mediterranean Islands, Cape Verde Islands, Canaries, etc., a public abattoir is the rule for every town; in the Dutch Colonies, in Java, Sumatra, etc., we find very fine specimens of modern public slaughter-houses after the best European models.

It has already been stated that the English public slaughter-houses are not worth consideration, as they are badly designed, generally separated from the cattle market (hence necessitating the driving of animals through the streets), and do not really serve their purpose, as private slaughter-houses nearly always exist in the same town. The pioneer of the modern public slaughter-house is Germany; it is to Germany we must turn to get the best and finest examples of public slaughter-houses. One hundred years ago France started the abattoir system when Napoleon built the Paris slaughter-houses, but as time went on it was Germany who took up the matter seriously and began building abattoirs and cattle markets that are to-day the wonder of the world and the pride of the Teutonic Nation. Switzerland, which has possessed public slaughter-houses for centuries, followed close on Germany; then Holland, Denmark, Scandinavia, the Balkan States, Austria-Hungary, and Russia.

Napoleon gradually compelled all French towns to close their private slaughter-houses and to erect public abattoirs; but magnificent as many of the French abattoirs and markets are, they are not on the same system as the German abattoirs, which are indeed a pattern for the world to follow.

Italy and Spain had public slaughter-houses in many towns in the Middle Ages, and these are gradually being brought up to

date. Madrid is now building its new abattoir, which will be the finest in Spain when completed.

Palermo (in Sicily) has drawn up a magnificent scheme for an abattoir, on the German model, fitted with cold storage and all modern appliances. A few months ago the writer was in Genoa, in Northern Italy, and when visiting the two old abattoirs belonging to the city, by the courtesy of one of the slaughter-house directors was shewn the plans of the new abattoir and cattle market for Genoa. This will probably be the finest scheme in the whole of Southern Europe and is just started ; it will take no less than five years to complete. Accustomed as the writer is to the splendid German public slaughter-houses, he could not fail to be impressed with the new Genoa scheme, which is at least equal in every way to the very best public slaughter-house and market existing in Germany.

The writer also visited San Pierre de Rena, near Genoa, where a most elaborate public slaughter-house has just been built for a town of some 20,000 inhabitants. This abattoir is on the German model and is built of stone and marble ; the slaughtering halls are lined with marble and are as light inside as out of doors, the most scrupulous cleanliness being noticeable in every detail.

Lyons, in France, is now building a new abattoir, on the German model, which will not be completed for five years. The great Paris slaughter-house at La Villette is being reconstructed on up-to-date lines at a cost of over a million pounds sterling.

WHAT IS BEING DONE IN ENGLAND.

It is really hard to realize that a country like our own which has such a fine sanitary system, such a complete system of public baths, etc., can tolerate for one moment the utterly puerile erections that have been "thrown up" from time to time and dignified by the name of "public abattoir." After carefully considering the matter, and having visited nearly all the public abattoirs of note in England, the writer can only state that the average English abattoir is a disgrace to our national intelligence and that a worse set of buildings could hardly be designed.

The London County Council has erected new public slaughter-houses at Islington, and is going to erect a further set of buildings there. The London County Council, instead of making a study of the best public abattoirs on the Continent, have put up buildings which are entirely unsuitable for modern public slaughter-house practice, out of keeping with the laws of humanity, and very unpractical for the handling of live stock and dead meat.

Some years ago the Admiralty went into the matter of humane slaughtering very carefully, and the outcome of it all was that the Naval slaughter-houses were built on an entirely different design, and stringent laws were passed with regard to

the handling and killing of animals. If the English public slaughter-houses that have been erected lately had been built on the lines laid down by the Admiralty, things would be better to-day.

WHAT IS ABSOLUTELY REQUIRED IN ABATTOIR BUILDINGS.

- (1) Slaughter hall for beasts, sheep and calves.
- (2) Cooling hall for beasts, sheep and calves.
- (3) Slaughter hall for pigs (containing scalding vats).
- (4) Cooling hall for pigs.
- (5) Gut washing room.
- (6) Lairage for beasts, sheep and calves.
- (7) Lairage for pigs.
- (8) Sanitary slaughter-house for horses, donkeys, diseased animals, etc.
- (9) Lairage for suspected animals.
- (10) Destructor for condemned meat.
- (11) Office.

Before going any further we must discuss the two different types of public slaughter-houses existing to-day. One is the *separate chamber system*, in which every butcher kills in his own room or compartment situated under one common roof; and the other system is called the *open hall system*, in which all butchers kill together in one or more great open halls. The *separate chamber system is utterly and entirely wrong*, and the English and Scotch can comfort themselves that they are the only people in the world who persist in building new slaughter-houses on this absurd principle. Most of the old French slaughter-houses are on the separate chamber system; but the French are pulling them down as fast as they can, and replacing them with abattoirs on the *open hall system*. The *separate chamber system* is nothing more nor less than a collection of private slaughter-houses built in a row and assembled at one common place and under one roof; a great deal of cruelty can take place undetected; there can be no supervision, for it stands to reason that the officials in charge can be in only one compartment at a time. The separate chamber system, on account of its extra walls, is more costly and difficult to keep clean.

With the hall system not only is the whole abattoir simplified and the cost reduced, but *full and thorough control* of slaughtering is assured by the officials in charge, and cruelty and dirty habits are at once detected. A disadvantage of the hall system is that it lends itself to petty pilfering, as a dishonest slaughterman can steal livers, hearts, etc., which are hanging about. This could easily be prevented by having a system of thin galvanised wire cages placed down one side of the hall; each butcher would be allowed to use a cage in which to hang the small parts of the various animals until they were taken away either to the cold storage or to the shop belonging to the owner.

There is, however, another difficulty in regard to animals being slaughtered in one great hall. On the Continent, as a rule, very quiet beasts are killed. Before these beasts are led into the slaughter hall, it is usual to put a leather mask over their eyes, so that on entering the slaughter hall they do not see their fellows in all the different stages of butchery, and are led quickly down the hall to the exact place in which they are required. In England we have very restive beasts to handle; and it is out of the question to mask them; this means that on entering the slaughter-hall they are confronted with carcasses in all stages of dressing and other animals being slaughtered. This is not right, and various designs have been thought out to get over the difficulty.

The British Admiralty, after great consideration and extensive visits to abattoirs in England and throughout the Continent, drew up the following rules for all Admiralty slaughter-houses. The essence of the rules are given briefly as follows:—

All animals awaiting slaughter to be kept entirely apart from the actual slaughtering, and not to be within sight or smell of the same.

No animal must be killed in view of another animal.

No animal to be slaughtered until all traces of the animal previously slaughtered have been cleared away.

All animals to be stunned before blood is drawn.

The result of the Admiralty commission was the erection of a model slaughter-house at Gillingham, Chatham Dockyard, and eventually all the Naval slaughter-houses were remodelled after the Chatham style. It is with some satisfaction that we note that whatever may be the bad points of England as a nation, directly anything connected with the British Navy comes on the scene, we are at once brought into touch with efficiency and good organisation; and it is owing greatly to the splendid way in which the Admiralty and all those connected with the Admiralty Commission acted that we have a better state of things in our Naval slaughter-houses. Arthur Lee, Esq., M.P., acted as chairman to this Commission, and was most thorough in all he undertook.

CHATHAM NAVAL SLAUGHTER-HOUSE, GILLINGHAM, CHATHAM DOCKYARD.

The stunning hall is provided with screens made of glazed bricks, some 5ft. high; THE SPACES BETWEEN THESE SCREENS ARE ALL VISIBLE FROM THE SUPERINTENDENT'S OFFICE. (See Fig. 13.)

The stunning hall is separated from the dressing hall by a wall fitted with self-closing doors. When beasts are to be slaughtered, they are put in the waiting pens, then, one at a time, they pass into the roping pen, and the door is shut. A noose is then thrown over the animal's head, the other end passing through

one of the killing rings. Another door is opened, and the animal goes forward and between a pair of the screens. He is immediately pole-axed and falls to the ground ; his throat is cut to draw off the blood, and then a hook and wire is attached to one of his legs ; the other end of this wire passes round one of the windlasses and the dead carcase is dragged through the self-closing doors into the dressing hall, where it is skinned and disembowelled. *The stunning partitions are immediately swilled with a hose pipe.* Not a speck of blood or filth can be seen. The next beast is driven into the roping pen, noosed, and coaxed forward between a pair of the screens ; the beast can see nothing but glazed brick walls and the self-closing door which separates him from his comrade which has been slaughtered, and which is now in a state of disembowelment on the other side of the self-closing door. It is a splendid scheme, and the only fault the writer could find is a detail that could be altered with a little trouble. For instance, a beast is in the left-hand pen, a noose is thrown over its head and it is intended to draw it up to the killing ring in the space 2. The slaughterman opens the gate and the beast goes forward. Now, naturally the beast will go forward in a straight line into division 1 ; but they require him in division 2 ; this will mean several minutes' delay turning him out of division 1 into division 2, and blows may have to be given to get him round ; even then he may make an obstinate dash into division 3 or 4, hence more delay and possibly rough handling. It is absolutely essential when designing slaughter-houses to have the buildings so arranged that animals have not to be driven more than absolutely necessary round right-angled corners ; and when beasts are roped, the buildings and pens should be so arranged that it is only necessary for beasts to go in a straight line, and there should not be any adjoining passages through which a beast may make a dash.

Fig. 14 shows the author's suggested alteration to overcome the difficulty just named. The office has been removed to the side of the building and raised, say, 8ft. ; the superintendent still has full command of the stunning compartments. Each compartment has a roping pen to itself, and directly the door is opened the beast cannot go anywhere except straight forward to one of the killing rings.

Some delay is caused in a slaughter-house of this class due to the dragging of the dead carcases through the self-closing doors from the stunning partitions to the dressing hall. This is done in the Admiralty slaughter-houses by a hand winch situated in the dressing hall, and takes about five minutes. In a large slaughter-house this delay is serious, and a better result would be obtained if the hand winches were replaced by electric winches.

The type of slaughter-house in use in South America has much to recommend it. The beasts can be stunned outside the slaugh-

ter hall, and are brought into the hall on a tray running on rails.

The stunning pen is placed at the entrance to the slaughter hall, and the sides are high enough to prevent a beast seeing over the top when he is in the pen. The bottom of the pen consists of a trolley running on rails. When the pen is ready to receive a beast, a door is closed and another opened. A beast is driven into the pen, and the second door closed; the beast WITHOUT ANY PREVIOUS ROPING is stunned by a man standing above him on a platform; the door is opened, and the stunned carcass, lying on a trolley, is pushed on the rails down the hall to the place where it is required, and the trolley returned.

The ideal abattoir will possibly be constructed so that all animals can be stunned *without roping*; the time thus lost, especially with a big beast, is considerable, and if an ideal system can be devised in which roping can be dispensed with, not only will a great saving in time be effected, but the animals will be saved unnecessary inconvenience and astonishment; animals do *not* like being roped, and the wilder they are the more trouble they cause. Very quiet beasts and fat pigs do not seem to mind, but a wild bullock or restive porker may prove troublesome.

When beasts are to be stunned by shooting them with a rifle a man can stand above them and fire down. If, however, they are to be stunned with a pole-axe or other instrument it is safer to rope them in order to steady their heads to receive the blow; though in many abattoirs on this plan the beasts are still stunned without roping.

THE CHICAGO SYSTEM.

A long passage is divided into compartments by sluices which are raised by pulleys. The beasts are driven into the passage and the sluices let down leaving a beast in each compartment. A man walks along a platform with a sledge hammer and stuns each beast just below him. The sides of the passage are also on the sluice system and are then raised, and the carcasses come out by the floor of each compartment tipping up and ejecting the bodies of the stunned beasts into the slaughter hall. The sides are then let down, the sluices opened and the passage is then filled with a fresh batch of animals. At Chicago, and many pig-killing installations, the pigs are simply caught up by their hind legs and bled to death. We need not enlarge on the American slaughter-houses, be they in North or South America: the writer has never seen or even heard of a really good one in those countries. They would not be admired in a European country, but for all that they must be mentioned in this paper, as *some* of the ideas they have adopted are very suggestive; for instance, the type which allows a beast to be stunned *without roping*, in a pen *outside* the slaughter hall.

ENGLISH PUBLIC ABATTOIRS.

Fig. 15 is a typical plan of a modern English public abattoir shewing the department for killing beasts and possibly sheep as well.

The beasts to be slaughtered are driven in batches from the lairage into the waiting pens. They are roped one at a time in the waiting pens and dragged into the slaughter hall, pole-axed, bled and dressed, the carcasses being sent off to cool in the cooling hall. The method of procedure is as follows: The slaughterman goes to one of the waiting pens and throws a noose over a beast's head, the other end of the noosed rope (or chain) runs through one of the killing rings. Directly the beast has the noose over his head, the gate of the pen is opened and then the trouble begins. *First*.—The beast may be in any position and comes out of the waiting pen with difficulty; meanwhile all the other beasts in the waiting pen get excited, and try to rush out, and another man has to drive them back. After several minutes have been wasted, the beast comes out alone and the gate of the pen is shut. *Second*.—The noosed beast has to go into the slaughter hall through one of the open doors; he is already outside the door, but the rope that is pulling him in runs through one of the killing rings, and this rope or chain is pressing hard against the sides of the doorway; power is thus lost, and there will be a struggle to get the beast round a right-angled corner into the hall.

Third.—When the beast is in the hall, he has to be turned round into position with his back to the cooling hall and his head held down near the killing ring to receive the blow of the pole-axe.

From careful observation in a number of slaughter-houses the writer thinks that from four to eight minutes time (and sometimes considerably more) is lost on getting each beast into position to be slaughtered.

Fourth.—This system of having waiting pens just outside the slaughter hall, where all the other animals awaiting their turn can see more or less what is taking place inside, cannot be too strongly condemned. It is a barbarous thing, and no design should be passed that has been drawn up on this system.

On the Continent it is the rule to have no waiting pens at all; but to keep the lairage *entirely separate* from the slaughter halls, and to lead the beasts one at a time from the lairage to the slaughter hall as required. This can be done with quiet animals but is out of the question with the wilder class.

Fig. 18 shows a design by the writer which is quite simple and effective and does away with cruelty and loss of time. The lairage is quite near the slaughter hall though *entirely separate*. The beasts are driven one at a time straight from the lairage through the doors into the roping pens. The doors are

then closed, and a noose is thrown over the beast's head; the other end of the noose passes through a slot in doors and is continued through the killing rings. Directly the beast is noosed, the doors are then opened and the beast goes forward in a straight line up to the killing ring, the slack rope being pulled in as he goes forward, little or no pulling being required. Great care should be taken in designing abattoirs, that the intervening courtyard slopes *away* from the lairage into the slaughter hall so that no blood can possibly find its way out of the slaughter hall.

We will discuss the design drawn up for a model abattoir. (Fig. 16).

This design is by R. S. Ayling, F.R.I.B.A., of 8, Dartmouth Street, Westminster, consulting architect to the London Model Abattoir Society; certain features were put in at the writer's suggestion, and the general scheme is based on the Admiralty model at Chatham.

If the Admiralty practice of stunning partitions is to be adopted on an extended scale, some arrangement must be made so that all the stunning partitions can be viewed by an official who will check all clumsy slaughtering and rough handling of animals, and who will also undertake to see that each partition is washed clear of blood, etc., before another animal is brought on the scene. If this control is not provided for, the stunning partitions will lapse into the objections of the separate chamber system, where control of all compartments at once by an official becomes impossible.

The abattoir shown in Fig. 16 is a very large one, and is the outcome of a great deal of thought. It will be noticed that a cold storage room is provided, and that the carcasses can be run on the overhead rails straight from the cooling halls into the cold store without crossing open roadways impregnated with dirt and dust.

A passage always should separate the slaughter hall from the cooling hall, and another passage should separate the lairage from the slaughter hall, so that both the live animals and the carcasses should be free from the fumes and smells of slaughter; though in modern practice the slaughter halls are so clean, airy and light and the slaughtering carried out under such conditions of cleanliness that even in the slaughter hall itself there is really no unpleasant smell.

In Fig. 16 all the stunning partitions are viewed by an overhead gallery, on which one or more officials take up their stand and control the slaughtering. The offices of the Abattoir Director and Veterinary Surgeons are situated in the middle of the overhead gallery, where a good view can be obtained. The veterinary surgeons are the men in charge of an abattoir, and it is their duty to prevent cruelty and clumsiness.

In the hall type of abattoir without the stunning partitions, veterinary surgeons see each animal killed at the same time that they are attending to their other duties ; but if we add these stunning partitions we must add an official to control them.

Fig. 17 is typical of a modern Continental abattoir, showing the arrangement of the main buildings only. A truly wonderful sight these places are ; the great halls are one mass of glazed brick, and the lairages equal in exquisite cleanliness to a gentleman's hunting stable. Each slaughter hall is under the charge of one or more veterinary surgeons and an officer in uniform. In the middle of the hall or at the side is generally a glass office. The carcasses can be run from the slaughtering halls direct into the cold store by overhead rails, and every detail of the machinery has been carefully considered, the engine room being generally the last word in progress and finish.

It is hard to analyse one's feelings after seeing these splendidly equipped establishments on the Continent and returning to England to see our miserable attempts at abattoir building at home, put up anyhow, anywhere, and left without any control worthy of the name ; the veterinary surgeons in England (when an abattoir possesses any, which by the way is a rare thing in this country) hold a lower social position than in any country in the world, and their responsible and arduous duties are not appreciated, as are those of a family doctor. On the Continent a veterinary surgeon puts "Doctor" in front of his name. The Abattoir Director should be a veterinary surgeon himself and a man of sound social standing. The Abattoir Director on the Continent holds the same position socially as the manager of a large bank and lives in a fine residence on the site of the abattoir.

We must now consider the handling of pigs, sheep and calves. These animals can be handled with rapidity and ease, but require special treatment.

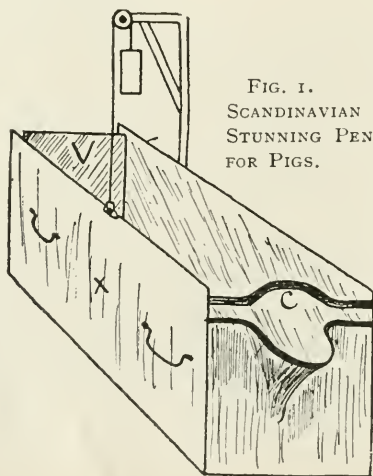


FIG. 1.
SCANDINAVIAN
STUNNING PEN
FOR PIGS.

PIGS.

It is usual when killing pigs to drive a batch of them into a pen, stun them one after the other with a mallet or pole-axe bleed them and drag the carcasses out for dressing, and fill the pen with another batch. This is not a very satisfactory way. They see each other stunned and bled, and it requires great skill to stun pigs first blow when they are walking about loose.

Fig. 1 shows a Scandinavian pen which holds one pig at a time for stunning, and directly he is stunned allows of the removal of the body and the entrance of a live pig.

The door *v* is pulled out and a pig driven into the pen. The door *v* is then pushed forward till it pushes the pig's nose under the bar *c*, the pig is then stunned with some instrument, and falls senseless; another door is raised, the carcass pulled out, bled, and dressed. The door is then lowered and the pen is ready for another pig. This pen is thought a great deal of in Scandinavia, and is actually used in country private slaughter-houses. (By Scandinavia the writer means Finland, Norway and Sweden, all countries taking up public abattoirs and humane slaughtering very strongly.)

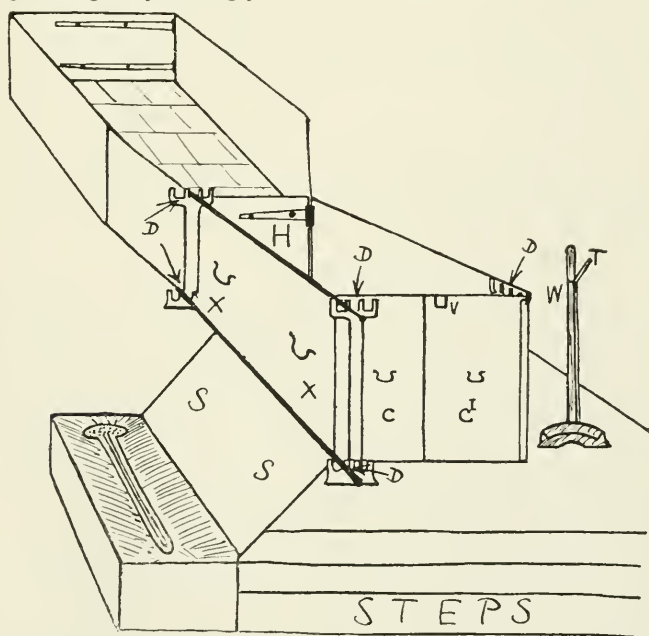


FIG. 2.—AUTHOR'S DESIGN FOR PEN TO ENSURE RAPID HANDLING OF ANIMALS.

Fig. 2 shows another design by the writer which allows of greater adjustment for various sized pigs and very rapid handling.

The waiting pen is filled with pigs ; a door H is opened and a pig enters pen. Door is closed. The pig is then stunned with an instrument. The floor of this pen works on a hinge and can be actuated by a lever W. The lock T of the lever is released and the floor drops pulling the lever with it ; the stunned body of the pig rolls down the incline SS on to the bleeding block AA. Its throat is then cut while it lies in a senseless condition, and immediately after a chain is attached to one of its hind legs and the body lifted head downwards so as to draw off the blood. When the bleeding has ceased the carcase should be lowered into a scalding tank to scald off the hairs, the crane should again be made use of to remove the carcase from the tank for dressing.

The live pigs in the waiting pens and the pig in the stunning pen never see their surroundings or each other killed ; no roping is required, and consequently there is no squealing and kicking.

This stunning pen can be used also for sheep and calves and these animals can be treated in a similar way. The Chicago system is to haul the pigs up by their hind legs while they are alive, plunge a knife into their throats and let them bleed to death, a proceeding which would be treated as a criminal offence in Germany, and some other countries, where all animals must by law be stunned before bleeding. The idea of letting pigs bleed head downwards is a good one, but they should be stunned first.

Fig. 19 shows the best Continental practice which, however, can be considerably improved upon. The pigs are driven into the pens, stunned, bled, and pushed into the scalding tanks ; after scalding they are removed by cranes to the tables and scraped, then they are hung on hooks for dressing.

Down one side of the great slaughtering hall are the stunning pens, underneath these pens are the scalding tanks, and next to the scalding tanks are the scraping tables. Each stunning pen is connected with waiting pens placed outside the building by doors. The waiting pens are filled with pigs, and a few at a time are admitted into the stunning pens, stunned with a special instrument, bled, and the carcases pushed into the scalding tanks. After that a crane does all the rest, first removing them from the tanks to the scraping tables and from the scraping tables to another part of the hall for disembowelment.

The weak point with this system is that each pig sees another killed, and before it is stunned it has to be steadied by a little rope passing round its hind leg. The other end of the rope passes through a ring.

With special stunning pens such as have been described, no handling of pigs would be necessary, and therefore *no squealing*, nor would the pigs be able to see their surroundings. No time is lost through roping, and directly the pig is stunned the

slaughterman tips open the floor of the pen by a lever and the carcase is ejected for bleeding.

All modern abattoirs have cranes, and use them for handling dead pigs, but, curiously enough, few abattoirs kill pigs by letting them bleed head downwards, and, if they do, seldom stun the pigs first, except in Germany, Switzerland, Holland, Denmark and Scandinavia.

SHEEP AND CALVES.

In the best Continental abattoirs the sheep and calves are placed in pens outside the slaughter hall, which are high enough to prevent the animals from getting any view of their surroundings. The animals are brought into the hall one at a time and laid on a crutch, their legs generally tied, and they are then struck on the head with a club and afterwards bled. Frequently calves are stunned with a hammer while they are standing, which is a far better way. The practice of laying animals on a crutch previous to stunning is not satisfactory. It means loss of time and the animals suffer from astonishment and fear.

Abattoir experts are decided that some form of stunning pen, such as has just been described for pigs, can also be used for sheep and calves. Directly the animal is stunned in the pen, the floor can be made to tip the body out on to a table for bleeding and dressing. *Humanity and efficiency should go hand in hand*, and the most humane abattoir of the future will no doubt be the most efficient and practical in every way.

We have now discussed briefly the different types of abattoirs, and the way animals and dead meat are handled in them. Before leaving this part of our subject let us make a short survey of the abattoirs of the world. Those of Germany are the best, and all the best abattoirs in and out of Europe are more or less on the German model. New Zealand has some good establishments.

In India and the Far East, China and Japan, the abattoirs are mostly not up to modern requirements. As far as the writer knows, Russia can teach us very little. As regards Egypt there is a particularly fine abattoir and cattle market at Port Said, and in Northern Africa, at Algiers, Tunis, etc., the French are erecting splendid new abattoirs on the German system. The Spaniards and Italians are reorganizing and rebuilding their abattoirs on the German system and so is France, a nation which has some magnificent specimens of the old-fashioned type of abattoir, not only in their large cities but in their country towns. Lisbon has a very fine abattoir, but it could be very greatly improved upon, being some twenty-five years old or more. Some of the large Italian towns have excellent abattoirs and markets which are many years old, Rome and Milan being well worth a visit. The Balkan States are copying Germany as all the rest of Europe are doing.

The finest abattoirs in the world are now to be seen in Switzerland, Germany, Holland, Denmark and now in Scandinavia, which is the latest part of Europe to take up the question. The Belgian abattoirs are on the French style and we need waste no time there. Greece has primitive abattoirs mostly, and Turkey has no public abattoirs at all, though the plans are drawn up for a modern public slaughter-house for Constantinople.

The writer will now give a short sketch of a first-class Continental public slaughter-house. Let us imagine ourselves in a large German city of 500,000 inhabitants. We alight at the main railway station and ask for the public slaughter-house ; we board the tram and are soon out in the suburbs, and see laid out before us a set of buildings surrounded by allotment gardens, and frequently by parks and open fields, though in some cases the abattoir is surrounded by residential property, it being an exploded idea that an abattoir must needs be isolated, for modern science and hygiene have made such progress that a modern abattoir is no more a nuisance than an ordinary lavatory. We alight at the main entrance gate, having on one side the Director's residence and garden and on the other side offices, hotel, restaurant, and sometimes a post office, and the ordinary caretaker's residence. We pass through the gates, enter one of the offices, and obtain a ticket of admission for a few pence.

As a rule all Continental abattoirs are open to adult men and women, a small charge being made in Germany ; this system of admitting the public ensures a fair amount of humane treatment towards the animals, and the public can see for themselves that meat inspection and hygiene are scientifically carried out.

It is owing to this very fact of publicity that abattoirs have made such progress in late years, especially in regard to the humane slaughtering movement. The presence of ladies especially has had a great deal to do with the reforms that have been carried out, and many men and women have given up their time and money to perfecting humane slaughtering appliances ; the great movement of humane slaughtering having been started by a lady in Germany, with the result that in a few years Germany stood head and shoulders above any country in the world, not only in regard to her magnificent abattoirs, but in her methods of killing animals. She was, however, followed quickly by Switzerland, Denmark, Holland and lately Scandinavia and Austria Hungary. The Parisians are very proud of their two fine abattoirs, one of which is combined with the cattle market and takes up some 170 acres, and picture post cards can be bought bearing views of the handsome buildings.

Having purchased a ticket we pass inside the grounds ; the first thing noticeable is the amount of space and the handsome grass plots and trees between the buildings. The cattle

market adjoins the abattoir, is invariably under cover and is quite a different affair to the average cattle market in England. Whitewash is not generally seen, but glazed or smooth bricks are used. The writer has seen cattle markets in Germany which would take away the breath of the average Englishman ; huge covered glazed brick halls fitted with marble slabbed pens, etc., glass offices occupied by officials taking charge of every detail of the organization ; a truly wonderful sight. The animals arrive by train or in special conveyances to the arrival platform, and from thence they pass into the market and are sold ; from the market they pass into the lairage to await slaughter. Every living animal brought on the premises is inspected alive by a qualified veterinary surgeon, then again after killing, and finally the carcass is examined when it is ready to leave the building.

In practically every civilized country in the world except England and the rest of the United Kingdom, veterinary surgeons, duly qualified and trained, are the only men allowed to take charge of a public slaughter-house. In England the meat inspection is a sheer farce, carried out by people who are not experts, and the English butchers, not to mention the public, suffer in consequence. In North America the meat inspection is indifferent, and when North America sends meat to Germany in tins with " passed U.S.A." stamped on the tins, all the respect these tins receive is a prompt order from the Chief Veterinary Surgeon for the covers to be at once removed, the German veterinary surgeons rightly trusting to no one but themselves.

Near the slaughtering halls are the gut washing rooms and triperies lined with glazed brick, lit by electricity like all the rest of the buildings, and fitted with hot and cold water. Then comes the destructor for destroying condemned meat, a sterilizing apparatus for sterilizing doubtful meat, which, after being dealt with in this apparatus, is sold at a nominal price in a special shop on the premises and open to the public. Then there is a horse slaughter-house, and baths and changing rooms for the slaughtermen and staff. The smallest Continental abattoirs possess a horse slaughter-house, and a sanitary slaughter-house for unhealthy animals whose carcasses will be destroyed. The writer has seen in Holland an abattoir fitted with a billiard room for the slaughtermen, and has known of others where a gymnasium is fitted up for their use ; a large abattoir nearly always contains a pathological laboratory for examination of trichinosis.

Certain parts of condemned animals and also bones are treated in the " Powdervill " apparatus. This consists of a large rotating iron cylinder containing rollers inside ; the organs and bones to be destroyed are put into this apparatus and crushed and at the same time subjected to high-pressure steam ; when the process is finished the result is excellent manure which

is sold at a profit. Blood is sometimes converted on the premises into manure and food for animals, and many large abattoirs contain a water-softening plant.

Every abattoir, large and small, is now beginning to have a cold storage room and to make its own ice, electricity, etc., frequently they make ice for sale as well. Yet with all these luxuries the Continental abattoir not only pays, but helps to relieve the rates. Why? Because everyone must slaughter in them, no private slaughter-houses are allowed, and all meat inspection and traffic in live stock and dead meat is centralized and properly organized, and the by-products turned to profitable use on the spot; fat and tallow rendering, blood converting, and the manufacture of manure being dealt with on the premises. There being a good supply of water on the premises it is not unusual for some towns to combine the public baths with the abattoir.

A great deal of horse meat is eaten on the Continent, there being no objection to eating healthy horses; it is purely and simply an English prejudice. The horses are inspected just the same as the other animals, the healthy ones killed and sold and the unhealthy ones killed and the carcase burnt. There are usually two horse killing rooms, one for healthy horses and another for unhealthy horses. Sausages are frequently made in the abattoir in special rooms; these rooms and the sausage machines being models of cleanliness and under the charge of a veterinary surgeon.

It will be seen at once what gross hypocrisy it is for the English as a nation who themselves possess the worst slaughter-house system (or rather lack of system) in the civilized world, to criticize foreigners about eating horses and bad meat. The amount of bad meat, not actually diseased meat, but meat more or less tainted, sold to the English poorer classes is very considerable. If the abattoir system existed in England a very large portion of the meat now sold would find its way to the abattoir destructor and not on to the market, while a very large quantity would have to be sterilized first in the sterilizer, a machine which subjects doubtful meat to high-pressure steam and destroys all harmful germs.

The few so-called inspectors who walk round the English shops and private slaughter-houses cannot see every piece of meat, and, being unqualified men compared to trained veterinary surgeons, often do their work very badly; they may do their best, but they cannot do impossibilities.

Briefly, we can now sum up the essential points in designing an abattoir. The abattoir and cattle market should be combined and placed near railway sidings; the abattoir should have its lairage entirely separate from the slaughter halls but so constructed that no time is lost in handling animals. The floors of

the stunning compartments, as well as the floors of the slaughter halls, should be constructed of such material as will not allow animals to slip or fall down easily. The walls of all the buildings should be lined with material which can allow of swilling down with water from a high-pressure hose pipe every day.

The slaughter halls, cooling halls, and cold storage, if the latter is fitted, should be so placed that the carcasses can be pushed on overhead tracking rails one from the other without loss of time or crossing large roadways. Gut-cleaning rooms should be provided where the entrails are dressed and cleaned ; it is not unusual in modern abattoir practice for these rooms to be very smartly fitted up in order to impress the necessity of cleanliness on the workers.

HUMANE SLAUGHTERING OF ANIMALS.

Even as far back as 1886 the Swiss law provided that animals should be stunned before blood was drawn, and prohibited the Jews from killing by their own special method of bleeding to death without previous stunning ; but it was Germany again (which had by 1890 established a highly organised public abattoir system) who took the matter up with great thoroughness, and after extensive enquiries decided that animals must be stunned before blood is drawn.

Denmark, Holland, and Scandinavia gradually followed Germany and Switzerland's example, though the Jews were allowed to slaughter in their own manner on religious grounds. Finland, however, has just passed a law compelling the Jews to stun their animals previous to bleeding, and Russia is trying to do the same, if it has not already actually done so. So far so good. But now another difficulty arose. Stunning animals in the early days was performed by striking the animal a hard blow on the head with a hammer, pole-axe, or club, various types of weapons being used ; but no one can foretell with certainty if the first blow of such a weapon *will* stun the animal and render it senseless at once. When stunning is carried out by a *competent man* armed with a suitable instrument it is painless.

There is one method of *paralysing* animals which makes them *appear* stunned while they are really fully conscious. This method is called "pithing," and is a great deal practised in the Latin countries : it consists of severing the spinal cord with a stab of a stiletto or knife just behind the animal's head. This causes the animal to drop paralysed, but he retains consciousness for a while, and feels the cutting of his throat. Beasts are killed in Spain, Southern Italy, and South America this way, but in Northern Italy it is usual to stun with a sledge hammer. Germany and Russia now have laws prohibiting "pithing," and the author believes that this is also the case in Scandinavia.

Abattoir veterinary surgeons are greatly to be praised for the

reforms they have brought about in the methods of slaughter and the general organization. On the Continent the abattoir veterinary surgeon is a professional man, and possibly the author of one or two standard works on slaughtering and abattoir designing.

Not long after the law was passed in Germany compelling animals to be stunned, it was seen that all was not well; great beasts frequently required several blows to stun them, and even small animals, especially sheep, were not always stunned every time at the first blow.

About 1900 a lady offered a prize of some £500 for the best instrument for stunning animals humanely. The great contest for the prize took place at the public abattoir at Leipzig, one of the most magnificent establishments it is possible to imagine. Every kind and class of instrument was tested from various countries, and the prize was divided between two inventions, both equally good.

The best known of these is called the "Behr" pistol, and is used in hundreds of abattoirs throughout Germany, Switzerland, Holland, and to a certain extent other countries, including many slaughter-houses in England; it is suitable for every class of animal except restless beasts who will not let people approach their heads.

STUNNING BEASTS, HORSES, DONKEYS, ETC.

The old-fashioned way was to strike these animals between the eyes (but rather above the eyes) with a sledge hammer, thus bringing on unconsciousness by *concussion*, though the brain itself is not actually touched by a weapon. This is the *very worst way of all* to stun large animals, as a very hard blow, and often several blows, must be given in order to be effective. This method is falling into disuse, and is only seen in out-of-the-way places in Europe, Northern Italy, and many towns in France.



FIG. 3.—POLE-AXE.

Some two or three hundred years ago the pole-axe (Fig. 3) was invented, as butchers realised that an instrument to penetrate the skull and touch the brain was required. The pole-axe is made in various types, but the principle is the same in all, that is, a hollow, circular, sharp-edged punch A punches a hole in the animal's skull and comes out easily. This instrument in the

hands of a competent man rarely fails to stun any class of beast first blow. It is used throughout the United Kingdom and in many of the best French, Dutch, Austrian, and German abattoirs, and when properly handled does its work splendidly. In the best abattoirs nowadays it is usual to shoot with a special pistol any beast that has a particularly shaggy forehead, so as to run no risk of having to deliver a second blow. The pole-axe, unlike the sledge hammer, *penetrates* into the brain, causing the beast to drop unconscious even if a very hard blow is not delivered ; but in the hands of a bungler it becomes a terrible weapon, and where first-class men are not to be had a special pistol or gun should be used.

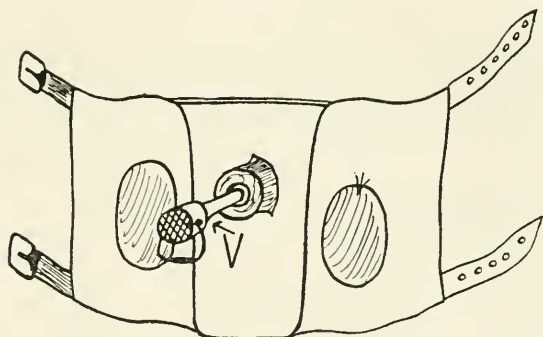


FIG. 4.— BRUNEAU MASK.

Fig. 4 is the Bruneau mask, very popular in Switzerland, Germany, and France, and to a certain extent in Denmark and Scandinavia ; it is not used in England, as our beasts are so restive that they will not allow this mask to be strapped on their heads. The Bruneau mask was invented by a Frenchman ; it is strapped on to the beast's forehead, and the hollow cutting punch V (pole-axe type) placed in a round slot in the front between and above the eyes. The punch is then struck with a mallet, which drives it home into the animal's brain. This is a good apparatus in some ways, as a clumsy man can hardly help driving the punch home with a broad-faced mallet, but even with this apparatus more than one blow has sometimes to be given when stunning a thick-skulled beast. In many abattoirs the men are fined for failing to stun an animal with this apparatus at the first blow.

Both the foregoing methods are dependent on skill and strength, and the Bruneau mask cannot honestly claim to be superior to the pole-axe when the latter is handled by a good man.

Fig. 5 shows a type of pistol of which thousands are in use all over Europe and to some extent in other continents ; it is only used as a rule on beasts, and is known in England as Greener's

Patent Cattle Killer, though the original inventor was Sigmunds, the Abattoir Director and Chief Veterinary Surgeon of Bale Abattoir, Switzerland. In this instrument a cartridge is inserted,

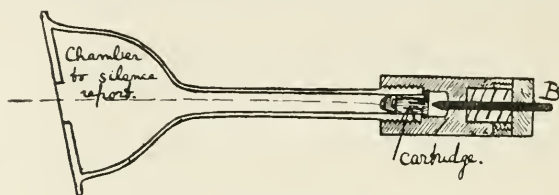


FIG. 5.—"GREENER'S KILLER."

and the instrument is placed on the beast's forehead; the pin B is then tapped with a little mallet, exploding the cartridge and driving the bullet into the animal's brain. It is a simple instrument, but not practical for wild cattle.

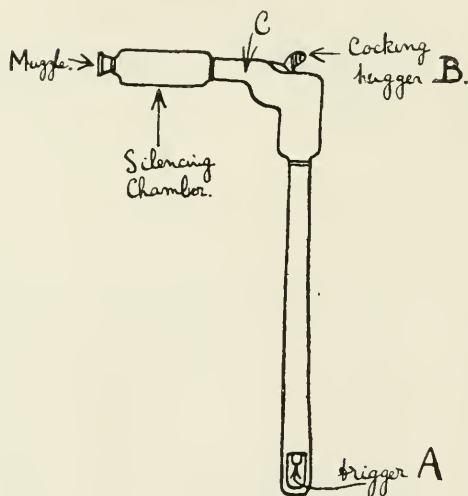


FIG. 6.—R.S.P.C.A. APPARATUS.

Fig. 6 shows the latest instrument invented by the Royal Society for the Prevention of Cruelty to Animals, and though it has only been out two years or so, hundreds are already in use in public and private slaughter-houses. We have wild animals to tackle in England, and something had to be invented which would allow the slaughtermen to stand clear of the animal's horns and fire. This instrument answers the purpose well. A cartridge is inserted at C, the trigger B cocked, the muzzle placed on the beast's forehead, and at the same time the slaughterman can stand away from the beast, and, if necessary, behind him or at

the side—this instrument having been made right-angled for that purpose—the trigger A is then pulled, disengaging the cocked trigger B, and firing the cartridge.

All instruments of this class fire a bullet into the animal's brain; there is some danger on this account, and there have been occasions on which the bullet has come out again of the animal's body and killed a bystander, but these accidents are so rare as to hardly be worth consideration.

The pistols which won the international prize at Leipzig in 1900 fire no bullet at all, and the best known and most widely used is the "Behr" pistol (Fig. 7).

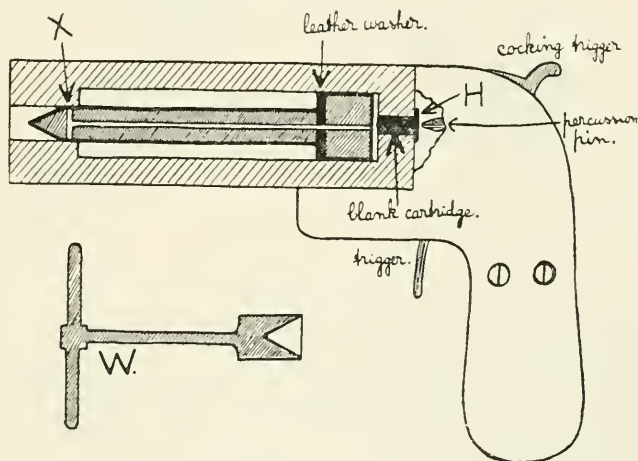


FIG. 7.—BEHR PISTOL.

The plunger is pushed back into the position shown in the drawing by means of a handle w. The breech is opened and a blank cartridge inserted at H. This cartridge contains powder, but no bullet. The breech is then closed, the pistol placed against the animal's forehead and the trigger pulled. The cartridge explodes, and the expanded gases drive the plunger forward into the animal's brain, the gases escaping down the plunger and out through holes at x diffusing themselves all over the animal's brain. The writer has seen this instrument used on the largest oxen and on quite small animals, such as sheep, and it is, in his opinion, one of the finest instruments in existence, though wild animals are so restless that difficulty occurs with them, and with beasts of this class the R.S.P.C.A. gun is better. The "Behr" pistol is used in many of the best German slaughter-houses and in Switzerland and other countries, including many private slaughter-houses in England.

There are certain abattoirs on the Continent where every kind

and class of animal is shot, the cost working out at about $\frac{1}{2}$ d. per cartridge per animal.

STUNNING PIGS.

In the best German, Swiss, Dutch, and Scandinavian abattoirs pigs are, as a rule, stunned with the Kleidsmidt bolt (Fig. 8). One slaughterman places the end of the instrument, containing the sliding punch c, on the pig's forehead. The punch slides up and down in a collar h. As soon as the instrument is in position

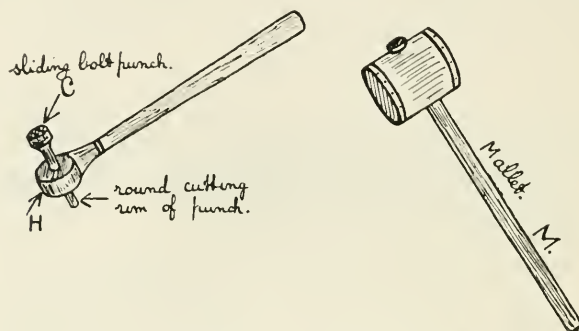


FIG. 8.—KLEIDSMIDT APPARATUS.

on the pig's forehead another slaughterman strikes the punch with a heavy mallet m, driving the punch home into the pig's brain. This is a very efficient instrument. In the German abattoirs a fine of three shillings is imposed for not stunning a pig at the first blow with this apparatus; but in many abattoirs the rule is not always enforced.

All instruments for stunning dependent on skill and strength are apt to fail at times, and in the ideal abattoir all stunning should be carried out by shooting instruments, and this is actually done at Utrecht, Holland; but there are abattoirs in existence on the Continent where only the larger animals are shot before bleeding, it being found that small calves, lambs, and young porkers can safely be stunned at the first blow with a mallet or the Kleidsmidt bolt.

Fig. 9 shows the *Percuteur Pilet* used for shooting pigs at Utrecht and one or two other Dutch abattoirs. Pigs having, as a rule, a soft skull, can be stunned more easily with this instrument; it is never used on other animals; the "Behr" and bullet-firing pistols being used for all the other animals at Utrecht. The *Percuteur Pilet* was named after Pilet the inventor, who was an engineer in charge of the machinery of one of the Dutch abattoirs. His idea was a spring gun. To set the spring place the gun on the wall (Fig 10) by means of the hooks and rests v v. The rod r engages on the catch c, the handle w is pulled down, and the very strong spring xx is pulled back and set by the trigger. The

Jol

FIGURE 16 - Plan shewing suggested arrangement of abattoir designed by RS Ayling, FRIBA and the Author to meet the points raised in the paper

A diagram of a scrap metal yard. In the foreground, a long wooden bench is labeled "SCRAPING TABLE". To the right, a row of scrap metal bins is lined up against a brick wall. The bins are labeled with letters: "H" and "S". A crane is lifting a bin labeled "H" from the row. The bins are arranged in a row, and the crane is positioned to the left of the row. The brick wall is on the right side of the diagram.

FIG. 10.—ARRANGEMENTS OF PANS, SCALDING TANKS AND SCRAPING TABLES IN MODERN GERMAN ABATTOIR.

FIG. 9.—“PERCETEUR PILET.”

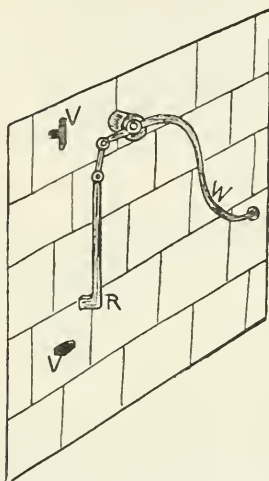
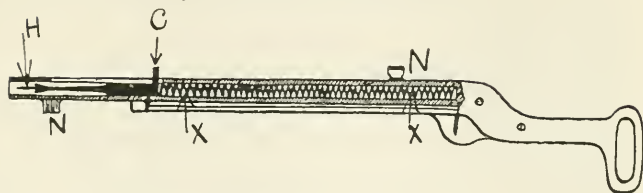


FIG. 10.
APPARATUS TO PULL BACK
SPRING OF
“PERCETEUR PILET.”

gun is now unhooked, the muzzle placed against the pig's forehead, and the trigger pulled; this releases the spring, and the spike *H* is driven into the pig's brain.

This is a good instrument, but a lot of time is wasted hooking and unhooking the gun, so that in large abattoirs something very much quicker is needed. The “Behr” pistol is very suitable for pigs, as it leaves no bullet in the brain.

SHEEP AND CALVES.

Sheep are the very hardest of all animals to stun, because they have such thick skulls. The British Admiralty when drawing up its rules for humane slaughtering was not greatly in favour of stunning sheep, and suggested that if the operation of stunning was not performed by a first-class man it would be better not to attempt it at all, but simply to bleed the sheep.

Even in the very best abattoirs abroad and in the Admiralty slaughter-houses at home the stunning of sheep with mallets and clubs is most unsatisfactory; these animals frequently require a second blow, and sometimes a third or fourth; even then they nearly always recover consciousness before they die when stunned this way. Some abattoirs in England prohibit the stunning of

sheep, knowing well what a hard business it is to carry out by force. Even the striking bolt apparatus, such as Kleidsmidt's, is utterly unsuitable, as it requires two men to handle it, and probably another man to hold the sheep.

The only method left to stun sheep painlessly is by shooting. The "Behr" pistol does this splendidly, for not only do the sheep meet a painless end, but they can be stunned in their natural position by one man. The sheep are brought out from the pens one by one, the slaughterman catches hold of the animal by his muzzle or one of his horns, places the pistol to his forehead and fires; the sheep collapses instantly and never recovers, the spike of the pistol having been driven right into the brain. Sometimes sheep and calves are stunned with a bullet-firing pistol called the

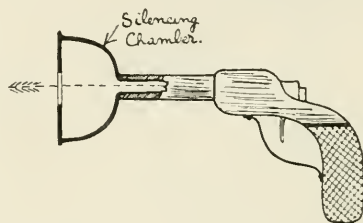


FIG. 11.—LANGLÉ PISTOL.

"Langlé" pistol (Fig. 11). This is a splendid little instrument, and is an ordinary pistol fitted with a silencing chamber, which reduces the report to practically nil. Sheep and calves can be killed with this instrument at the cost of about 2s. 6d. per hundred, the cartridges being very cheap; the pistol can be made repeating.

There is, however, a slight danger about using bullet-firing pistols for sheep and calves, as the bullet may come out of the neck and strike a bystander; there is also some objection to leaving a bullet in the animal's brain. For small animals a bolt-firing pistol, such as the "Behr," is the best. Many experiments have been carried out of late years as to the effect of shooting animals, and the conclusion generally arrived at is that shooting in no way hinders bleeding nor affects the meat.

Butchers who are against all reform declare that shooting hinders bleeding and taints the meat. After years of costly and detailed experiments this has been found NOT to be the case, and the very best abattoirs shoot all their animals, though as a matter of fact there are very few abattoirs at present which are so advanced as this.

Calves can be stunned by a heavy blow from a blunt axe or mallet; on the Continent these mallets are not heavy enough, and frequently calves are not stunned with one blow; the stunning of sheep and calves, even in some of the best Continental

abattoirs, is open for improvement, especially in the case of sheep. In private slaughter-houses, where only a few animals are killed every week, shooting instruments are seen at their best.

In Germany and other countries machines are sometimes kept in the abattoir on which butcher apprentices may practise stunning animals, and no apprentice is allowed to stun a living animal until he has proved his efficiency on the "dummy" apparatus

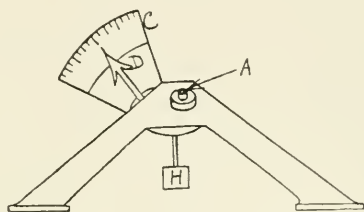


FIG. 12.—APPARATUS ON WHICH TO PRACTISE STUNNING.

before the Director. Fig. 12 shows one kind of apparatus in use, though there is more than one kind. The apprentice has to strike the knob A squarely so as to overcome the balance weight H and drive the hand D up to the required position on the dial C.

THE MECHANICAL ENGINEERING SIDE OF ABATTOIRS.

Nearly all modern abattoirs on the Continent are fitted with cold storage plant, make their own electric light, and besides this possess a destructor for bad meat, and a sterilizer for doubtful meat. In a large abattoir, as seen at Berlin, Leipzig, or Dresden, the engine-room will be centrally situated and possess several water-tube boilers and two horizontal compound steam engines direct coupled to alternators; these engines are generally worked with either the "trip" or "Corliss" gear, and are condensing. Several engines are used for driving the ammonia refrigerating plants as well as the water-softening apparatus.

In Germany the water softening is carried out by means of a large tower, engines being used to pump the water to the top of the tower, from whence it descends through a softening apparatus. This tower frequently has more than one function: it is used for water softening, acts as a smoke shaft for the boilers, and at the very highest point of the tower is a large cistern for high-pressure water service. The tower frequently contains an illuminated clock and bells, and is sometimes highly ornamented. Steam engines are preferred to gas or oil engines in an abattoir, as hot water and steam have always to be in use for cleansing the carcasses of animals, therefore it is not worth while to have two separate plants. The boilers that supply steam and hot water are also used for driving the engines. The large abattoirs and

now even the smaller ones have their own engineers. At Leipzig abattoir there were three or four trained engineers in charge of the engine-room, which was as large as a London generating station ; it would seem as if modern public abattoirs go in for the best of everything, for the abattoirs the writer has seen in Germany and Holland contained the finest plant of engines and boilers that could possibly be imagined, the highest workmanship being noticeable in every detail, the engine-room being lined with with glazed bricks and having tessellated floors. It is usual to place the engine-room adjoining the cold storage, so that the brine pipes come straight through the cold storage to the ammonia machines in the engine-room. The destructor is so constructed that while it is in use for destroying bad meat no gases can escape without first passing through the fire, so that no smell can reach the outer air. The destructors are made in various types, one of which resembles an oven. The sterilizing plant is very simple, and consists of a large cylinder into which doubtful meat is put and subjected to very high-pressure steam.

In the slaughtering halls the overhead tracking is interesting, as it allows, by means of movable switches and points, for any carcase in any part of the hall to be run into any other part of the hall or into the cold storage direct without leaving the hooks. All the drain traps are fitted with special intercepting grids to prevent large substances passing, as well as grease interceptors. All large abattoirs have a small workshop for repairs. Electric motors for hoisting carcases of beasts are now coming into vogue. At Islington (London) they have been installed not only for beasts but for sheep and calves. They are certainly useful for hoisting up the carcases of beasts, but they have been abandoned in general practice for the smaller animals. These fads are beginning to make the modern abattoir much more complicated than is really necessary. A destructor, and perhaps a sterilizer, is a necessity, while cold storage is now considered a *sine qua non*, though it adds greatly to the cost. In England many butchers have their own cold storage room, so that the value of a huge cold storage room at the local abattoir is open to question.

Every part of the abattoir, and also the market, both inside and out, should be fitted with hydrants, with a set of hose pipe to each hydrant, so that every part of the buildings can be kept in a state of most scrupulous cleanliness, and in summer the whole place can be kept cooler and free from flies. The slaughtering halls of the modern abattoir are lit at night by electric arc lamps, incandescent lamps being used in the offices and outhouses. The ventilation of the slaughtering halls and lairages can be regulated. At Vienna and Buda Pesth abattoirs a most complicated system is used for changing the air in the lairages, fans and large flap valves being used, so that the ventilation can be regulated at will.

CONCLUDING REMARKS.

There is some satisfaction to think that New Zealand has now adopted a stringent meat inspection by veterinary surgeons who have been trained at the Royal College of Veterinary Surgeons in England, and they alone are allowed to have charge of the abattoirs, while the Continental system of triple inspection is the rule, the animals being first of all inspected alive, then after slaughter, and the carcase finally passed before leaving the abattoir. How long the present condition of affairs is going to be tolerated in England is a question. Directly the words "public abattoir" are mentioned here, the butchers rise up and say that only vegetarian food faddists and humanitarians require them; this means, then, that all people in the world except Turks and Hottentot savages, etc., are "vegetarian food faddists," humanitarians, and (another term the butchers are very fond of using) "abattoir architects." This latter definition finds great favour among the hostile butchers, and is thought a very good joke.

And yet with the same breath the butchers in this country are now shrieking for uniform meat inspection by *veterinary surgeons* (not plumbers, etc., who have taken a six months' course in meat inspection and go about as inspectors!) throughout the United Kingdom. Engineers and architects will be well advised to study the best Continental abattoirs before drawing up their plans, and it is hoped that the points and sketches demonstrated in this paper, the result of world-wide study and practical experience extending over many years, may not be wasted.

DISCUSSION.

The **President** moved a vote of thanks to the author of the paper. The subject dealt with was an important one, and he regretted that there were not more persons present at the meeting. He was greatly surprised to hear that we were so deficient in this country with regard to public slaughter-houses. It seemed very remarkable that legislation was not introduced to remedy the evil. The author's statement to the effect that there was no system of meat inspection in England was certainly startling. He should like the author to give the dimensions of some of the foreign abattoirs referred to. It was very pleasing to hear that the Admiralty had taken up the matter, and they were building an abattoir on modern lines at Gillingham. Several years ago he witnessed some prize cattle being killed. The poleaxe was used in each case, and in a few instances two blows were required to stun the animal. As to the sheep, they were run into a sort of outhouse on to a wooden grating, and their throats cut. Pigs were dealt with in the same way. He was glad to hear that stunning took place now with all animals, as it appeared to be a

more humane method. He wondered whether animals could be rendered unconscious prior to stunning, as human beings were before an operation.

Mr. Dodington said that stunning carried out by a competent man rarely failed, but that on the other hand failures sometimes occurred, and therefore the best slaughter-houses had thrown up the antiquated methods of slaughtering with poleaxes and mallets, and had replaced those things with pistols.

The vote of thanks was carried unanimously.

Mr. Dodington acknowledged the vote of thanks and recommended those engineers who were called upon to design abattoirs to go for examples to those countries which had the best slaughter-houses. In London £32,000 was spent in putting up in Islington a slaughter-house which was more than a hundred years out of date.

Mr. R. S. Ayling, being called upon to open the discussion, said the worst of hearing such a paper as the present was that it was so conclusive, that little was left to be discussed. **Mr. Dodington** had referred to the absurdly few abattoirs which existed in England and Wales. There were only 104, and that meant practically none in proportion to the population; as the majority were small and obsolete. One of the diagrams might be interesting as showing how much meat was killed in the whole of the public abattoirs of England and Wales per head per annum. We ate 119 lb. per head per annum, only 12½ lb. of which was killed in the public abattoirs.

Another diagram related to a number of English towns having so called public abattoirs, and showed how little meat passed through them. In the case of Bolton, only 1½ lb. out of 119 lb. per head per annum was killed in the public abattoir. In the case of Whitley Bay they killed 2 lb., although at Croydon they actually killed 107 lb. But he had taken a fair average. Croydon was hardly a typical example because it supplied the places round it. Taking the population of Croydon alone, the figures would be hardly fair. This state of things was accounted for to a great extent, as **Mr. Dodington** had said, by the enormous competition of the private slaughter-houses. For instance, in Middlesbrough they killed at the abattoir 6½ lb. per head per annum. In that place, with a population of less than 100,000, there were actually 39 private slaughter-houses competing with the one public abattoir. Until, as **Mr. Dodington** had said, it should be made compulsory that when a public abattoir was built, the private slaughter-houses should be closed, and all the butchers should kill in the public abattoir, it would be impossible to make any real progress.

The author had referred to the Edinburgh abattoir. That was the latest and decidedly the best; but, then, Scotland was

head and shoulders above England in that respect. Scotland had, or, at any rate, was gradually getting, a complete abattoir system. In the new slaughter-houses at Edinburgh it was rather curious to note that while in England the butchers very strongly objected to dwarf partitions in the slaughter court, the Scotch butchers insisted on having them.

Mr. Dodington had referred at great length to the humanity in killing animals, but he had forgotten to mention another and equally important point, and that was humanity to the employees. One could not doubt that the killing of animals for food must be a repulsive business, and that, when the men did their business in a well ordered and hygienic building where they could have the amenities of life, such as baths and decent surroundings, those things must have a splendid effect on them.

The opposition to public abattoirs came solely from the butchers and could be summed up in one word, "compensation." He referred to compensation for closing the private slaughter-houses and compensation for any meat which was found to be tuberculous. It was impossible for the greatest expert to tell whether a beast was tuberculous when it was standing in the open market. If the beast was bought by the butcher from the farmer, killed, and then found to be tuberculous, the butcher lost the whole value of the meat. He (Mr. Ayling) rather disagreed with some of his confrères in regard to this matter, for he thought that the butcher ought to be reasonably compensated in such a case as he had mentioned. This was a matter which ought to be settled at once.

Again, he thought that the butcher should receive reasonable compensation for having to close his slaughter-house, or what he called his "workshop." He was reading a paper on public abattoirs some little time ago, and the meeting was crowded with butchers. During the next week there was a leading article in one of the papers consisting of about half a column of virulent abuse of him and everything he said, except that the article did give him credit for one thing, and that was that the butchers should be compensated. The article stated that that was the only sensible thing that he said during the evening.

The author had made a slip in attributing the erection of the Islington abattoir to the London County Council. That abattoir was built, not by that body, but by the City Corporation, and it was paid for out of City Corporation funds. Before it was opened the members of the Corporation had made up their minds that it would not pay, and they had not been mistaken, for it did not do so. Even presuming that it was a public abattoir (and if so it was the only one they had in London) this result was not surprising, for only 9 lb. of meat per head per annum was killed at Islington. The London private slaughter-

houses killed about 20 lb. The rest of the meat was provided by foreign imports.

Unfortunately the London County Council had done absolutely nothing, although they had been pressed for many years, even in face of the fact that their own Medical Officer of Health, Sir Shirley Murphy, reported in 1898, "I am led to the conclusion that to provide public slaughter-houses to meet London's requirements would cost the Council less than some of the improvements undertaken by the Council under the Housing of the Working Classes Act. From the health point of view, such expenditure on public slaughter-houses would be incomparably more valuable." They had, however, one crumb of comfort from the London County Council; they were gradually closing the private slaughter-houses in London. One of the diagrams in the room showed the reduction in numbers between the years 1874 and 1888. From this it would be seen that during that time they decreased on an average by about fifty a year. Then the London County Council came into being, and since then the number had gradually gone down, except in 1897, when there was a slight increase. The number had gone down on an average about 22 a year from 1888 to 1910. There was an interesting point in the year 1891 when the L.C.C. made a new code of by-laws relating to slaughter-houses. In that year the number went down to the extent of 114.

Reference had been made by the author to the mechanical engineering part of the business, and he had said that in some Continental towns the public abattoir was the finest building in the town. Well, it was very charming, but it did not need to be so. A writer in one of the papers some little while ago stated that in his opinion buildings such as public abattoirs were "unfit for publication," and that they should be put underground like public conveniences, or hidden behind blank walls. Mr. Ayling thought that in this matter, as in most things, the happy medium was right. The buildings ought to express their purpose, and an abattoir could and should be made to do so, and should be properly equipped.

Mr. E. J. Silcock, although he was afraid that he could not add anything useful to the discussion, could certainly bear out the statements that had been made by the author as to the wretchedly bad provision which existed for the slaughtering of animals in the private slaughter-houses up and down the country. It had been his lot to have to inspect a great many slaughter-houses, and he had found the conditions to be most inadequate. When he was in the City Engineer's office in Leeds twenty years ago the Corporation had under consideration a proposal to provide public abattoirs, and, in order to carry out their scheme, they proposed to close all the private slaughter-houses in the

town. It was part of his duty to prepare plans of these slaughter-houses in order to furnish evidence before the Committees of the Houses of Parliament when the Bill was dealt with by them. This was the most ghastly job which it was possible to imagine. The whole office staff was sent out in relays to undertake the work, and no member of the staff could stand the work for more than a few days at a time. The filth, the smell and the whole atmosphere of the places were so disgusting that the staff could not carry on the surveys for more than a few days without having to take a holiday. Unfortunately the opposition of the butchers was so strong that the Corporation did not proceed with their Bill. Many of those private slaughter-houses were still in existence. The Corporation did provide a public abattoir, but he regretted to say that it was on the principle of private pens which the author had very strongly and, as he (Mr. Silcock) thought, very justly condemned. The Leeds abattoir was very little used for the reason that the butchers would not desert their own private slaughter-houses.

There was now a very excellent and much used slaughter-house in the city belonging to the Co-operative Society, and he believed that the very best meat in the town could be obtained there. He had had to inspect slaughter-houses in other towns, and had found that the conditions there were much the same as in Leeds.

One point which had always struck him was the large amount of bad meat which came to London. It was the general practice of the butchers throughout the eastern counties of England, when they got meat which was not of a satisfactory character and which could not be sold in their own towns, to pack it off to London. London was a sort of dumping ground of all the bad meat in the South of England.

Another matter which he would like to direct attention to was the undesirability of having the business of the knacker's yard carried on in the same establishment as the public slaughter-houses. It would, to his mind, give an opening for fraud, or at all events, cause a certain amount of suspicion that something which was intended for dogs might be used for human consumption ; and it seemed to him most desirable that the two branches of trade should be kept entirely separate.

Mr. Benedict wished to ask one or two questions. How were the public abattoirs maintained ? Next, did the shooting, or the poleaxing, or any of the other means employed for killing the animals, do any injury to the brain from the butcher's point of view, the brain being a delicacy much appreciated by epicures ? And how did the private slaughter-houses, shown in Mr. Ayling's diagram, come to be closed ?

Mr. R. S. Ayling, replying to Mr. Benedict's question as to the reason that some private slaughter-houses had been closed, said it was simply that they had not complied with the County Council's by-laws, or the licensee had not slaughtered an animal for nine months.

Mr. Aubrey Richardson asked whether the author of the paper had any suggestion to make for the exclusion of rats from slaughter-houses, and for the exclusion of vermin from the beasts before they were brought into the slaughter-house.

REPLY.

Mr. Dodington, in reply to the suggestion which had been made that the place for slaughtering horses should be separate from the rest of the buildings, said that, on the Continent, the two kinds of slaughter were kept quite distinct, although they were carried on in the same establishment. It was necessary that the horse slaughter-house should be near the ordinary abattoir, for the simple reason that the veterinary surgeons had to go backwards and forwards to the knacker's yard in order to inspect all the animals. On the Continent the horse slaughter-house was far away from the main part of the building, generally in a remote corner, and disconnected from the main building. Horses brought for slaughter came in at special gates and went along special roads. There was a small private door which separated the horse slaughter-house from the main premises, and the horseflesh was sold in separate shops away from the other meat, so that everybody knew that it was horseflesh. There was no trickery about it. There were special shops in the town for the sale of horseflesh. That was the strictest part of the whole of the arrangements in the Continental slaughter-houses. Any visitor could go to the horse slaughter-house from the other slaughter-houses, but he must as a rule get a special permit from the Director, and there were precautions against smuggling horseflesh into the ordinary slaughter-houses. The authorities of the place were very careful about that point. He thought that it was undesirable to have the knacker's yard away from the ordinary abattoir. They needed to centralise everything as much as possible. All slaughtering in Germany was under the immediate control of a veterinary surgeon and a "hall master," and though the horse slaughter-house was separate from the main slaughtering halls, a veterinary surgeon or a "commissionaire" was present during slaughtering.

The abattoirs on the Continent were maintained by the charges made for the slaughter of the animals. The fees varied a great deal. In England 1½d. had to be paid for every sheep,

and 1s. 6d. or 2s. was charged for oxen. On the Continent the charges were rather higher and meat was rather dearer, while as a rule the abattoir paid anything up to 15 per cent. It was undesirable that an abattoir should pay too much, because a high rate of profit would mean that slaughtering fees were high. Some of the crack slaughter-houses charged 4s. or 5s. to a butcher for killing a beast. That included insurance and everything that could possibly happen, and if the beast was diseased the butcher got compensation. This charge covered storage, lairage, and everything. He had never heard in any Continental slaughter-house a single word against the slaughter dues. What he had heard was the absolute amazement of the slaughtermen that there still should be a country in Europe that had private slaughter-houses in the towns. He had heard the separate chamber system condemned by the people using it. Slaughtermen admire and prefer the open hall system on the whole, and in Germany they had long ago forgotten that the separate chamber system existed.

His reply to the question whether shooting instruments injured the brain was that they did not do so if the process was properly carried out. When the brain of an animal which had been shot was going to be sold in the market for food it should be removed from the skull, and if it had been shot by a bullet from a pistol the bullet should be taken out and the brain cleaned and washed in salt water. Then it would be perfectly right. Considering that over 700 German slaughter-houses alone (to say nothing of Switzerland, Holland, Scandinavia, Denmark and certain places in Austria-Hungary) used the shooting arrangement, he did not think that there could be very much the matter with it. There were many abattoirs in which shooting was compulsory and in which no other method was allowed. He did not think that it could hurt the meat if it was done in a practical way, but proper care should be taken to remove the bullet after animals had been shot. Pigs were frequently killed with a Behr pistol (Fig. 7) to avoid the possibility of a bullet being chopped up with the meat.

Shooting instruments were used very widely now in the best slaughter-houses, and he did not think that there could be anything against it. But, if trouble arose sometimes, it would not be a good argument against shooting, nor outweigh the humanitarian argument. When one imagined what five or six blows with a poleaxe meant, it seemed as if one must sacrifice something for humanity. At Utrecht, in Holland, the inhabitants insisted on *all* the animals being shot.

December 5th, 1910.

THE WORKING OF THE "ROAD DEVELOPMENT ACT, 1909."

By REGINALD BROWN, A.M.I.C.E., F.S.I., M.Inst.M.&C.E.,
M.R.S.I.

IN submitting the following remarks on the above subject the author thinks no apology necessary as the matter of good roads is of vital importance to the community at large. "Good roads" may be said to indicate the degree of prosperity of any country or district.

The question of efficient means of approach to and from centres of population, and of means of communication between various parts of large towns, has been debated over and over again, but more especially since the highways of the country have been used for motor vehicular traffic. The highways are now to take their proper place in the scheme of internal development, and must therefore be constructed to carry the traffic likely to come upon them. The matter is so important, however, that it requires co-operation between the authorities and the users, and not only co-operation but sympathy by the users towards the local authorities and the occupiers of property abutting on the roads.

When the whole cost of improvements, reconstruction and widenings has to be borne by each individual authority the burden becomes a very heavy one. The use of the highways by heavy motor traffic has shewn up the weak places in the construction, and it is hardly fair, when a road which is quite sufficient for the needs of the district and for the ordinary traffic, requires to be widened, strengthened, or otherwise improved owing to its use as the chief means of communication with an adjoining town, that the expense should wholly fall on the local highway authority. The cost of such a work should be spread over a larger area and a share, at least, of the cost should certainly be borne by the extraordinary users of the roads. The time is not very far distant—if it has not already arrived—when all highways will have to be constructed with stronger foundations and with a more durable material to withstand the destructive action of the heavier and more rapid forms of locomotion.

One great step towards the attainment of good roads is the Act which forms the subject of this paper. The Act embodies the important principle that the users of the highways shall pay a

share of their improvement, and also that the area from which the money required for such works is drawn, shall be wider than the boundaries of individual highway districts. It now rests with the local authorities to co-operate whole-heartedly with the Road Board and vice-versa, so that a scheme or schemes may be devised to secure that the highways of the United Kingdom are second to none. But how is this work to be accomplished?

The Act of 1909 partly answers the question. It empowers the Treasury to appoint a body of persons, to be called the "Road Board," to carry out certain duties for improving facilities for road traffic and to administer a sum of money which is to be granted them by the Treasury—called the Road Improvement Grant. Just how much this grant will be is at present very difficult to estimate and it would serve no useful purpose to hazard a guess.

The powers of the Road Board may be summarised under two headings:—

- (1) Improvement of existing roads.
- (2) Making new roads.

Under the first heading the Board may make advances to County Councils and *other* highway authorities in respect of the improvement of existing roads, where such improvement is required for facilitating road traffic; and for the purposes of the Act the expression "improvement of roads" includes widening any road, cutting off the corners of any road where land is required to be purchased for that purpose, levelling roads, treatment of a road for mitigating the nuisance of dust and doing any other work in respect of roads beyond ordinary repairs essential for placing them in a proper state of repair. Roads include bridges, viaducts, and subways.

Under the second heading the Road Board may (*a*) make advances to County Councils and *other* highway authorities in respect of the construction of new roads, and may contribute towards the cost of maintenance of such new road, or (*b*) may themselves construct new roads.

The special provisions as to the construction of new roads by the Road Board are, briefly, as follows:—The construction of the road has to be approved by the Treasury after consultation with the Local Government Board, and before such approval is given the Treasury will see that the Road Board has given notice of their intention to make such a road to every highway authority concerned, and will consider any objections to the proposal which may be made by any such highway authority.

All roads constructed by the Road Board are to be public highways after construction, maintainable by and at the cost of the Board, or they may agree with any highway authority in whose district the new highway is situate to maintain and repair

that part of the road within the district of such authority. Provision is also made that communications between any existing roads or paths and the new road may be made, subject to the approval of the Road Board. In case the highway authority themselves are desirous of making new roads, the Road Board may give their sanction to such construction. The difficulty of acquiring the necessary land for road improvement and the making of new roads has hitherto been a serious check to the carrying out of schemes, because as soon as an authority requires land for such a purpose it is surprising to find how the value of the land has increased. The Act contains very helpful provisions in this respect. Land may be acquired by the Road Board for new roads for a distance of 220 yards on either side of the centre line of the road. The Board may also purchase land for offices and other buildings.

Highway authorities may also acquire land for the construction of new roads and the improvement of existing roads. The most important provisions are those relating to the acquisition of land *otherwise than by agreement*. Thus if the Road Board or any highway authority are unable to acquire by agreement, or on reasonable terms, any land required for the purpose of the Act, they may apply to the Development Commissioners for an Order empowering them to acquire the land compulsorily, and the Commissioners have power to make the Order. In many instances a little tact or moral persuasion will obtain from land owners the land really required, and this at a moderate cost—especially if the provisions of the Act are pointed out to them. In those cases where compulsory powers have to be obtained, the highway authority has to submit, in the first instance, a draft Order to the Development Commissioners putting in force the provisions of the Lands Clauses Acts, but the Order itself will contain important modifications of the usual form of Order made thereunder. The compensation payable has to be settled by a single Arbitrator, who has power to settle costs and disallow costs of unnecessary witnesses. No additional allowance can be made to the value of the land to be taken by reason of compulsory purchase, and the arbitrator in arriving at his award may allow an amount by which in his opinion the proposed work would benefit the remaining and contiguous lands belonging to the same owner. The sale of surplus land is not compulsory.

The financial provisions of the Act are of very great importance and interest. They provide that an advance to a highway authority may be either by way of grant or by way of loan or partly in one way and partly in the other, and shall be on such terms and subject to such conditions as the Road Board thinks fit. The financial aspect of the question will appeal more than anything else to local authorities. During the past few months

schemes of improvement have been suggested all over the kingdom, and the published accounts shew, if nothing else, that the highways are now receiving that attention which is due to them. The cost of dealing with the whole of the suggested improvements will, however, be very great, and the author is afraid that many of the suggestions will have to wait several years before they can be carried out, if such improvements depend wholly upon the grants to be received from the Road Board. It would form a very interesting document if the Road Board could see its way clear to publish, in a tabulated form, the various suggestions now being or at any time to be considered by them.

The Road Board are limited in their expenditure, as the sums expended out of income on the construction of new roads or the acquisition of land, or in respect of any loan raised for any such purposes, shall not, in any one year, exceed one-third of the estimated receipts of the Road Board for that year, but any receipts derived from the surplus land acquired by the Board for the purpose of making new roads, so far as they are applied for the purpose of construction of new roads, shall not be treated as part of the expenditure of the Board on new roads. The Board may also borrow on the security of the Road Grant for permanent works, but the total amount required for the repayment of principal and interest shall not exceed in any year the sum of £200,000. The legislature has therefore answered part of the question we have set ourselves to answer—by the provision of the necessary machinery and monetary assistance.

The appointment of the Road Board was the next important step, and the author thinks that the Treasury is to be congratulated on securing the services of such men as Sir George Gibbs, Mr. Rees Jeffreys, and Col. Crompton as chief officers—all are well known authorities on locomotion and transport, and are well acquainted not only with the needs of the country but also with the difficulties which beset local highway authorities in carrying out any necessary improvements.

The Road Board will now act as a "ring main" for supplying the "steam" generated by Parliament to the various administrative machinery represented by the Highway Authorities. Before such "ring main" can be connected up and "steam" supplied, in order that no "waste" may occur and that the largest amount of "steam" is supplied where it is most needed, the Road Board has commenced its life by ascertaining what improvements are really required. In July last they issued a circular letter to all highway authorities indicating certain procedure in relation to applications which are to be made to them for assistance. These applications at the outset are to be confined to those of an important and urgent nature. The Board state, in the circular letter referred to, that special consideration

will be given by them to proposals dealing with the following matters :—

1. Reconstruction of important roads, the condition of which is exceptionally bad and cannot be improved without reconstruction.

2. Widening of important roads which are dangerously narrow.

3. Surfacing with granite, basalt or other suitable material, treated with tar or other bituminous compound by some approved method, main roads or important district roads which already have adequate foundations, especially those on or just beyond the outer fringe of large towns and which have to carry a heavy traffic without aid from the rates of the towns they served.

4. Opening out of dangerous corners and alteration of dangerous gradients.

5. Strengthening and reconstruction of weak bridges which limit the use for commercial transport of roads of first-class importance.

6. Construction of new by-pass roads to avoid villages on main roads or important district roads where the conditions are exceptionally dangerous.

7. Acquisition in urgent cases, where building is imminent, of vacant land required for future widening of roads in urban and suburban areas.

The Board also suggest that, before applications are made for assistance in the carrying out of improvements, conferences should be held between the County Surveyor and the District Surveyors in each County, for the purpose of discussing the proposals to be made and of selecting those which should be submitted in the first instance for the consideration of the Road Board. The Board also significantly intimate that those proposals which are approved by the County Councils will receive first and most favourable consideration.

The Board therefore suggests that each County should form a complete "wheel," the "hub" being represented by the central authority—the County Council—and the "spokes" by the various highway authorities—the County and non-County Boroughs, and the Urban and Rural District Councils. It is evidently the intention of the Road Board that the Surveyors of the various authorities should form an expert Committee to consider the various schemes of each County, which clearly include County as well as District schemes, and after full discussion, and knowledge of the subject, report thereon to the County Council as to which schemes should, and which should not, in the opinion of that expert Committee, receive first consideration.

This suggestion places the Surveyors to the local authorities in a very peculiar position. In some instances the conference is

held at the offices of the County Council and consequently a great loss of time is caused. Further the selection of the most important schemes is one which the author thinks will not be attempted by any conference of Surveyors and a general principle only will be laid down. The author suggests that it would have been preferable for each Surveyor to confer with the County Surveyor on any scheme which he had to bring forward and lay his reasons before the County Surveyor why such scheme should be carried out ; it would then be for the County Surveyor to report to the County Council upon all the schemes submitted and for that Council to decide the order of priority for recommendation to the Road Board.

The author suggests that the order of consideration should be somewhat as follows :—

1. Main roads.
2. Main district roads, classified according to their importance.
3. Ordinary district roads.

Each class should then be subdivided under the headings given in the Board's circular letter before referred to. As a good deal of work is placed on the shoulders of already overworked officials the schemes, in the first instance, should be required to be submitted only in draft, and after the Board's decision has been given, the necessary details should be prepared.

Dealing with the Board's suggestions seriatim :—

1. *Reconstruction of important roads the condition of which is exceptionally bad and cannot be improved without reconstruction.*

The use of heavy motor traffic has found out weak spots in the roads, and the cost of remaking them sufficiently strong to carry such traffic is a serious burden on highway authorities. The author is quite aware that claims for extraordinary traffic are sometimes made, and sometimes *successfully* made, but this is not altogether a satisfactory proceeding, when it is borne in mind that heavy motor traffic has come to stay as part of the scheme for internal development of the country ; but the author is of opinion that when a road has been specially reconstructed to carry motor traffic then such traffic should not be allowed to use the weaker roads but should be compelled to use only those roads specially constructed for their use. The local authority should be the body who should certify what roads are fit and what roads are unfit to carry motor and other heavy traffic. The author is quite aware that even in this there is a difficulty, inasmuch as factories spring up in all parts of a district, and the roads leading to them are sometimes not of the best construction.

This is, however, a purely local matter, but when roads leading from one town to another are concerned the cost should not



COUNTRY MAIN ROAD DAMAGED BY MOTOR WAGON. (Photo by J. H. Golden Haverhill.)



BRENTFORD HIGH STREET.

[Photos by Wakefield, Brentford.]

be borne by any single local authority. It is to the latter class of roads that monetary assistance should be given and in this case the County Surveyor would be the official concerned. The author has several cases in mind where a large amount of damage has been done to main roads by heavy motor traffic. To give an instance :—A main road partly in an Urban and partly in a Rural District, total length about $9\frac{1}{2}$ miles, half a mile in the Urban District and 9 miles in the Rural District. The road was in West Suffolk and was an ordinary main road, constructed for the ordinary traffic of the district, the foundation being of gravel with a surface covering of flint, while that portion within the Urban district had a thin coating of granite. The roads had been kept in repair and maintained for £65 13s. per mile in the Urban district and £47 per mile in the Rural district before the advent of motor traction. The road, being the main road between two towns, began to be used by one heavy motor wagon only, to carry goods from one town to the other. The weight unladen was 4 tons 18 cwt. 2 qrs. and when loaded the registered axle weight on the back wheels was 8 tons and on the front 4 tons. Immediately after this motor wagon began to be used serious damage was done to the centre, cutting into it so as to form deep ruts and pushing the haunches out of shape. The cost of maintenance went up 100 per cent. in the case of the Urban portion and over 100 per cent. in the case of the Rural portion. It was manifestly unfair to burden the ratepayers of the districts with the extra cost entailed, but the authorities were only successful in recovering a portion of the expenses. One could mention several such cases, but by doing so the paper would be unduly lengthened.

2. The widening of important roads which are dangerously narrow.

Almost every authority in the Kingdom deplores the narrowness of some of its main thoroughfares, due sometimes to the want of sufficient foresight and sometimes to want of sufficient powers to insist upon wide roads, or from the fact that the road, after construction, has become an important means of communication. In some districts the cost of widening would be prohibitive, if borne wholly by the rates of any particular district. Many cases will occur to all of you, but as an instance of such an undertaking the author need only refer to the High Street, Brentford. This road is mentioned because it has the unique distinction of being the only road outside the Metropolis referred to in the report of the Royal Commission on London Traffic. The road is a main road from London to Hounslow, Slough, Reading and the West of England. It is so contracted by buildings on either side that the width is in places only 19ft. between the kerb stones and has running through it a double line

of tramway. The condition of this road has been a standing disgrace to the County of Middlesex for many years. As one who has known this road intimately for the past 20 years, and has had some experience in its maintenance, the author is convinced that the cost of widening such a thoroughfare to the requirements of a first-class arterial road would be prohibitive if wholly borne by the local authority. The author has it on good authority that a sum of about £350,000 would be required. Such a scheme should be dealt with on a much wider basis than even that of the Road Board. The District is too poor to pay even a small proportion of the cost and it is evident that the Road Board would sink a large proportion of its grant in such an undertaking. Such a case requires special Imperial assistance. Main roads, however, are not the only roads which require widening, there are in some districts important district roads which are dangerously narrow. This will, generally, be found to be the case where a "speed limit" has been fixed, or in roads towards the maintenance of which the County Council contributes, but which are not actually main roads. These roads are main lines of communication and must be dangerously narrow from the fact that there is a speed limit applied to them. The widening of such roads has hitherto been carried out in a piecemeal manner by the local authority because of the cost, but no doubt the Road Board when making a grant will take into consideration the extent to which the local authority has already met its liabilities in this direction. For such undertakings the author suggests that the Board and the County Council should make a grant say in the proportion of $\frac{1}{4}$ & $\frac{1}{2}$ respectively leaving the local authority to bear the remaining $\frac{1}{4}$. In addition to this the Road Board will no doubt be prepared to advance by way of loan the money required by the local authority at a low rate of interest and spread the repayment over a long period. In this way many improvements can be carried out at no very great cost to the present ratepayers.

3. *Dustless roads.*

The author has somewhat shortened the heading of item 3 of the Road Board's circular, as he thinks that it may be summed up in the heading now given. In all parts of England thousands of pounds have been expended by highway authorities, during the past few years, in treating the roads, with a view to dust prevention, either by putting down tar-granite macadam, tar-slag macadam, granite macadam treated with a bituminous compound or surface treatment such as tar dressing in one of its many forms, but much remains to be done. The whole question is one of £ s. d.

For the purpose of consideration the roads can be classified under two main headings.

1. Main roads.
2. District roads.

These can be again subdivided into—

1. Main roads :—Those repaired by County Councils, County Boroughs, Non-County Boroughs, Urban and Rural District Councils.

2. District roads :—Those repaired by County Boroughs, Non-County Boroughs, Urban and Rural District Councils.

To give an idea of the magnitude of the question of making dustless roads it is necessary to ascertain the mileage of highways. It is, however, difficult to ascertain this with any degree of accuracy as there are something like 1900 different authorities, in England and Wales only, having jurisdiction over the highways. Mr. Walker Smith, of Edinburgh, in his book on "Dustless Roads," gives the following figures as relating to England and Wales only:—

COUNTY MAIN ROADS IN URBAN DISTRICTS.

Repaired by County Councils ..	535	
Repaired by County Boroughs ..	1,870	
Repaired by Non-County Boroughs ..	1,242	
Repaired by Urban District Councils ..	2,376	
		6,023

COUNTY MAIN ROADS IN RURAL DISTRICTS.

Repaired by County Councils ..	16,933	
Repaired by Rural District Councils ..	6,527	
		23,460

ROADS IN URBAN DISTRICTS, OTHER THAN COUNTY MAIN ROADS.

Repaired by County Boroughs ..	6,946	
Repaired by Non-County Boroughs ..	4,612	
Repaired by Urban District Councils ..	11,374	
		22,932

ROADS IN RURAL DISTRICTS, OTHER THAN COUNTY MAIN ROADS.

Repaired by Rural District Councils ..	95,119	
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Total mileage		147,534
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For our present purpose it will be sufficient to accept these figures, but it is hoped that the returns which will soon be in the hands of the Road Board will be published, when possibly a more accurate figure may be obtained. It will be seen from the figures that some 118,000 miles of roads may be taken as district roads, not carrying through traffic, and 29,500 miles of main roads ;

23,500 miles of the latter being in Rural Districts and 6,000 miles in Urban Districts.

The cost of treating such a large mileage every year with tar, in one of its many forms, and as a surface treatment only, would cost a very great amount of money. Incidentally, however, it would find work which would be of great benefit. As the cost of surface treatment would be about three-quarters of a million per annum, it is obvious that the work must be done with a more permanent material. This material will no doubt take the form of tar-macadam, or something similar, and this is very apparent from the suggestion contained in the circular of the Road Board.

* Tar-slag macadam, manufactured in large quantities, can be laid at a cost of 2s. 3d. per super yard, for 3in. in thickness, and the cost per mile would therefore be £1,188 (say £1,200) for a road 6 yards in width. The cost of treating 29,500 miles would therefore be £35,400,000. It is fair to assume that the money for this purpose could be borrowed and the repayment spread over a term of years, and that such term would probably be 7 years for Urban Districts and 10 years for Rural Districts. If the money could be borrowed at $3\frac{1}{2}$ per cent., the annual repayment of principal and interest would be :—For the 7 years period, £16 7s. 1d. per £100; for the 10 years period, £12 0s. 6d. per £100.

Taking the mileage of roads as 6,000 for Urban districts and 23,500 for Rural districts the capital is allocated as follows :—

Urban Districts, 6,000 miles at £1,200	..	£7,200,000
Rural Districts, 23,500 miles at £1,200	..	£28,200,000
		£35,400,000

And the annual repayment of principal and interest is

Urban Roads	..	..	..	..	£1,177,500
Rural Roads	..	..	..	..	£3,391,050
					£4,568,550

To set against this item there is the present cost of maintenance, but, as this varies so much in different counties, it is difficult to strike a fair average—thus in the County of Middlesex—a county where the traffic is heavy owing to its proximity to the Metropolis—the cost is as high as £550 per mile, whilst in such a county as Merionethshire the cost is as low as £18 per mile. It may, however, be assumed that £200 per mile is a fair average for Urban main roads, hence we have the following figures :—

Capital cost of conversion £7,200,000.

Annual repayment of principal and interest £1,177,500.

Present cost of maintenance £1,200,000.

To the charge for repayment of principal and interest must be added the cost of treating the surface of the tar-macadam, (say every year after the third year), with a tar dressing, and some repairs to the surface. A fair amount to allow would be an average of £40 per mile for each year, this would represent £240,000, bringing the total cost per annum up to £1,417,500 or say £36 per mile more than now paid for the whole length (6,000 miles) of Urban roads to be converted into dustless roads. These calculations, however, assume that the whole of the roads shall be converted in one year and also that the cost of highway maintenance throughout the country shall be equalised. The latter principle would, no doubt, be opposed by those counties where the present cost of maintenance is low, and as this opposition would be reasonable the author approaches the question from another point of view. Taking the cost of a dustless road at £1,200 per mile—if the material is laid at 2s. 3d. per super yard—the annual repayment of principal and interest would be £196 5s., to which must be added, for annual maintenance, the sum of £36, making the total cost as £232 5s. 0d. per mile ; or putting the cost as high as 3/- per super yard the annual repayment of principal and interest and maintenance would, in round figures, be £300 per mile, hence it follows that in counties where the present cost of maintaining the macadam roads exceeds, say, £300 per mile, such roads could be converted into tar-macadam (dustless) roads without any extra cost to the county. In the case of those counties where the present cost is below £300 per mile per annum a small grant from the Road Board would be all that would be required to bring the provision of dustless roads nearer attainment. For instance if the cost is £200 per mile per annum at present then the county should be prepared to expend a further £50 per mile if the Road Board decided to give a grant of the remaining £50, and taking this figure over the whole 6,000 miles, as an average, the grant from the Road Board would be £30,000 per annum—not a very great amount considering the great benefits which would ensue to motorists from the provision of dustless roads. It is of course not at all possible, at present, to consider the question of tar-macadamising the rural main roads, as the cost would be very much greater than at present, but probably the case will be met by grants towards the cost of tar-dressing the surfaces.

The author does not suggest that the whole of the 6,000 miles should be converted in *one* year, but a very good start would be the laying down of certain main roads, such as a circular route round England, commencing at the Metropolis and reaching as far north as York, passing westwards to Manchester, southwards to Bath and eastwards to London, joining up with the more important towns on the line of route. An experiment of this

kind would demonstrate the great advantages of dustless roads to such an extent that public opinion would ensure the extension of the principle.

4. *Opening out of dangerous corners and alteration of dangerous curves.*

The advent of motor traffic has shewn the necessity of modifying the stereotyped right-angled junction of roads, especially main roads, and also the sharp curves which exist in many highways throughout the country.

The County Councils have expended, on fixing warning posts at such spots, a considerable sum of money which would have been better spent in removing obstructions. Right-angled corners and sharp curves not only entail considerable danger to the users of the roads, and especially to motorists, but also involve serious delays. In Urban Districts the cost of removing this form of obstruction will, in many cases, be serious, although much can be done by judicious foresight and moral persuasion when old buildings are removed to be rebuilt, and this the author suggests should be the procedure adopted, except in the more serious instances.

In the more rural parts of the country, and in urban districts not yet built upon, much can be done at little cost in the way of rounding corners and straightening curves. Landowners, if they are approached in the proper spirit are generally found willing to co-operate with local authorities in improving the roads. In some instances, known to the author and to many of those present, it may be considered more advisable to construct short by-pass roads rather than to patch up the present obstructions.

5. *Alterations where possible at reasonable cost of steep and dangerous gradients.*

What is more pitiful than to see a horse struggling up some gradient with a heavy load behind it? With a little cutting here and an embankment there, a good deal can be done at little cost, but the chief offenders in this respect are the railway and canal companies who have erected "over bridges" to carry the public highway. The older type of bridge has steep approaches, is narrow in width, and entirely insufficient for present-day needs. The growth of a district renders it essential that the gradients of these structures should be remodelled and the bridges widened to a proper width, and the author is of opinion that those companies responsible for the construction and maintenance of such structures should bear a fair share of the cost of such work.

The author is well aware that the companies referred to may claim that the widening etc., is only required to facilitate road traffic and is not required for the companies' traffic, but it must be borne in mind that it is partly due to the railway companies

that such traffic has increased, and it is as much to their interest, as to the public generally, that wide roads should exist, so as to facilitate the traffic to and from their stations and goods yards, as increased facilities mean increased revenue.

6. *Strengthening and reconstruction of weak bridges which seriously limit the use for commercial transport of roads of first-class importance.*

As highway authorities will have to strengthen the roads and bridges under their control the author cannot see why railway and canal companies should not be compelled to do likewise—or bear a fair share of the burden of the cost of doing so. There is, so far as the author is aware, no legal power to compel this, the bridges being originally constructed of sufficient strength to carry the ordinary traffic at the time of their construction. Of course railway and canal companies will claim that the owners of heavy motor vehicles—who in many cases act as keen competitors with the companies as carrying agents—should pay the cost of strengthening the bridges, and there is some force in this argument; but such arguments should not be allowed to stand in the way of commercial transport by road. Many of the bridges are too weak to carry the modern traffic, in fact heavy motor vehicles are forbidden to use them.

The author has seen a notice, such as the following, posted on an important bridge, “This bridge is insufficient to carry a heavy motor car, the registered axle weight of any axle of which exceeds *two tons* or the registered axle weights of the several axles of which exceed in the aggregate *four tons*, or a heavy motor car drawing a trailer of which the registered axle weights of the several axles of the heavy motor car and the axle weights of the trailer exceeding in the aggregate *seven tons*.”

What an admission of the weakness of the bridge! When it is borne in mind that this bridge forms the main link of communication between two parts of a rapidly growing district in the neighbourhood of the Metropolis, the growth being largely due to the advent of factories, and that to avoid the structure drivers of heavy motor cars would have to make a circuitous journey of a mile and a half, it is clear that such a bridge should have prompt attention.

The author has many times stood on this bridge when heavy motor vehicles have been passing; and the vibrations due to such traffic have been very apparent. Local authorities can, however, do much towards remedying this type of defect by watching carefully the extensions of the railway company in their district and insisting upon the strengthening of such bridges before their sanction is given to any extensions. Canal bridges are, however, in a different category. It is seldom that canal companies wish to extend their canals, and the chance of carrying out improve-

ments to bridges over canals will seldom occur, unless the road authority are prepared to pay the whole cost of the alteration. Things may, however, be different when the canals become the property of some central body and take their proper place in the internal development of the country.

7. *Construction of new by-pass roads to avoid villages on main roads or important district roads where the conditions are exceptionally dangerous.*

In connection with this matter it will be observed that the expense of purchasing the land required will not necessarily be heavy, as it is suggested that such by-pass roads are to be made to avoid villages on main roads, but it may also be more convenient to construct by-pass roads to avoid important *district* roads. Many cases will occur to the minds of those interested. The author could mention several where such a diversion would be advantageous. For instance the main Bath Road is exceptionally narrow through the village of Colnbrook in Middlesex, and the construction of a by-pass road at this point would be of great benefit. the cost of the necessary land would be low and the scheme would not be a burden on any authority. In many urban districts the construction of a by-pass road in lieu of the present narrow main road would facilitate traffic. As grants will no doubt be made with the object of facilitating *through*, as opposed to *local*, traffic it will in many instances be cheaper to construct new by-pass roads instead of interfering with the present road. The author would again refer to the case of the Brentford High Street, as this is a case which exemplifies the necessity of something after the nature of a by-pass road. Such a new by-pass road could be constructed to avoid altogether the narrow main road, but would, the author is given to understand, cost more than the amount suggested for the widening of the existing road. The Road Board will no doubt take these points into consideration before grants are made for widenings, and grants will in all probability be given only for the construction of new by-pass roads instead of towards widening existing roads where the new road can be carried out at a cheaper rate.

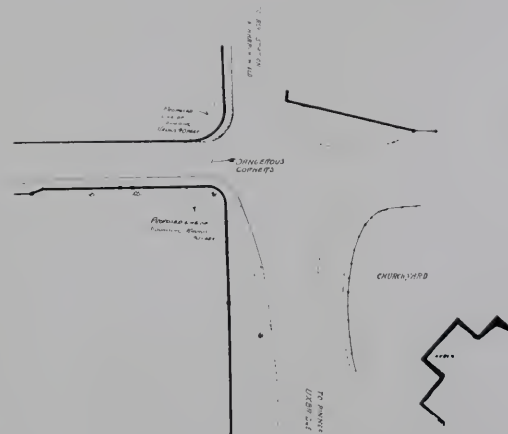
8. *Acquisition in urgent cases where building is imminent, of vacant land required for future widening of roads, especially in urban and suburban areas.*

In growing districts, especially in the neighbourhood of large towns, the problem of widening existing roads during development is always being faced and no doubt the Road Board will receive many applications under this heading only. The officials of local authorities are fully alive to the advantages of wide roads, and many instances are known to the author, from personal knowledge, of the great services rendered to the community, by the surveyors of local authorities being able, without ostentation



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or hope of reward, except the knowledge that they are doing their duty, to secure valuable improvements at little or no cost to the district they serve. Piecemeal improvements, however, have had their day, but, although excellent in their way, they do not go far enough. The point is to secure that in future the width of new streets and the widening of existing thoroughfares shall be effected, not at haphazard, but in general relation to the needs, not only of the particular district but also that of the immediate neighbourhood, and in pursuance of some fixed policy which can be followed out as opportunities offer themselves. To carry out this properly there should be some authority—such as the County Council in conjunction with the Road Board—which should have power to classify roads according to the user. The Royal Commission, previously referred to, suggested the following widths for streets :—

Main avenues—140ft. wide.

First-class arterial streets—100ft. wide.

Second-class streets—80ft. wide.

Third-class streets—60ft. wide.

Fourth-class streets—40-50ft. wide.

To decide on a proper classification would require careful consideration and co-operation between highway authorities, owners of property, County Councils and the Road Board, but the author suggests that some such arrangement as the following would be satisfactory.

First-class arterial streets:—All existing main roads contiguous to town areas.

Second-class streets:—All subsidiary main roads, *i.e.*, those not contiguous to town areas.

Third-class streets:—All district main roads.

Fourth-class streets:—All minor district roads.

By the adoption of some such classification the whole work of widening roads might be proceeded with on well defined and uniform lines throughout the country.

There still remains the question of the construction of new roads by the Road Board itself. Probably it will be many years before such works are taken in hand, as the construction of new roads of any magnitude is a serious and costly undertaking. It is evident, however, that some such construction will have to be carried out, because it is urgently needed, especially in the neighbourhood of the Metropolis. The importance of having suitable main roads leading out of London will increase year by year owing to the increase of road traffic, the increase of motor-driven vehicles and the extension of the tramway system. It will become more difficult year by year to obtain these new outlets owing to the ever increasing belt of buildings and the increased value of the land. Several suggestions were made in

evidence before the Royal Commission on London Traffic, such as the construction of new roads in different directions out of London and also of a circular road about 75 miles in length at a radius of 12 miles from St. Paul's. Both these proposals would entail a large capital expenditure, but the longer the schemes are delayed the greater will be the cost. If such a "ring road" as last suggested was constructed, the main roads now entering the Metropolis, together with any new outlet roads to be constructed hereafter, could be linked up and so provide a means of rapid and convenient transport, so essential to the well-being and importance of the first city of the world.

A very good, and practical, illustration for the making of a new outlet from London was that suggested in the London Motor Roadways Approach Bill in 1908. The Engineers for the scheme were Messrs. W. & C. S. Meik & A. A. Campbell Swinton. By the courtesy of these gentlemen the author is able to exhibit the plans and sections of the proposed work. The illustration is given to shew the practicability of such an undertaking, and is important in view of the powers of the Road Board.

Although the author has extended the paper to a much greater length than originally intended, he feels that he has but dealt with the fringe of the subject and this only in a brief manner. Much more could have been written on this important subject, but if the paper gives rise to an interesting and useful discussion the author's object will have been attained.

In conclusion the author has to thank the following gentlemen for assistance readily rendered in making this paper complete:—Mr. Pettitt, Surveyor of Highways, Clare U.D.C., for the photo illustrating damage to roads; Mr. O. Claude Robson, M.Inst.C.E., Engineer to the Willesden U.D.C., and Mr. Webb, Surveyor, Hendon U.D.C., for copies of plans of dangerous corners; Mr. Croxford, Surveyor to the Brentford U.D.C., for photos of Brentford High Street.

DISCUSSION.

The President said that he was sure that all those present were very much indebted to Mr. Brown for his excellent paper. The subject of the paper was of great importance at the present day to all engineers on account of the advent of mechanical traction. They were all pleased to hear the remarks in the paper about the Road Board. He noticed recently in a technical paper that applications for grants to the extent of £5,000,000 had been made, and the Road Board he believed had about £1,000,000 available.

With regard to the author's remarks about each surveyor conferring with the County Surveyor it appeared to him that

this would involve rather too much work for the County Surveyor, and he should have thought that it would be far better for surveyors of adjoining districts to meet together to formulate a scheme, and then propound it to the County Surveyor.

With regard to materials he was rather sorry to see that the author did not lay much stress upon the foundations of roads. It was all very well to talk about coatings, but it appeared to him that if a road had not a good foundation it would not be of much good.

Mr. Norman Scorgie said that what would be the outcome of the suggestions which had been made to the Road Board remained to be seen. He feared that the majority would be pigeon-holed and would be little heard of for some time to come. The institution of the Road Board had brought to light a number of proposals which would never have been heard of but for the possibility of getting something from somebody else. Many instances had arisen showing that each individual authority thought that its own child was the most important and the one which should be dealt with by the Road Board before everything else. He agreed with what had been said by the President with regard to conferences with County Surveyors. A County Surveyor had his own children to see to, and he would naturally look after his own brood first; and, naturally, to keep well in the eyes of his authority, was going to urge to the utmost the suggestions in which he had the greatest interest. He (Mr. Scorgie) thought that the suggestion of the author that it would be preferable that the surveyors of each authority should meet the County Surveyor was a good one.

He noticed that the author did not think much of the surfacing of roads. It was admitted that such surfacing was only a palliative, and that the dose had to be repeated year after year. Taking the Road Board's suggestions as to the construction of roads, they did not seem to have very much faith in slag macadam because they particularly referred to granite, basalt, or similar material. It was some 25 years since he had his first experience with tarred material for roads. Granite was all very well as long as the tar remained on the surface. The trouble in a good many of the main roads was that the granite was not hard enough. How slag was going to stand the strain of the ever increasing traffic he failed to appreciate. The more one looked into the matter the more fully one appreciated the magnitude of the task which the Road Board had to deal with.

Mr. C. S. Meik said that he noticed that the author had referred to the proposal for a Motor Road Approach to London put forward by his firm in 1908. A Bill to authorize the proposal was put before Parliament; but it never came before a Committee,

owing to the opposition of, more particularly, the Middlesex County Council, who objected to a road which would, they said, sever the county, and the scheme was dropped. Now there was a chance—rather a remote chance it was true—of its being taken up again. The matter had been put before the Road Board, and they had seriously considered it, not in the light of a motor road, but as a new road forming a means of access from the west into London both for motor vehicles and for ordinary traffic. The Middlesex County Council looked into it more favourably now, he believed.

It was essential in large cities that the traffic on the new roads should cross over the existing roads in order to avoid blocks. If it did not the present evil would be intensified, because the additional traffic would be thrown upon already overcrowded streets. The new subway under Kingsway was a good example of what might be done ; but it was only a fragment, and he was afraid that in the course of time it would be rather a troublesome fragment, because the traffic from that subway was discharged upon the Embankment, which was already overcrowded, and the same thing happened at the other end, causing frequent blocks.

The only way to get over the difficulty would be to take the traffic into the country on a high level so that it would clear all cross traffic, and the new road should be so constructed that it could be prolonged afterwards, as the towns extended in either direction.

The author gave the cost of tar slag macadam as 2s. 3d. per superficial yard. In connection with the Motor Road Approach Bill he (the speaker) had found on obtaining estimates that he could not get a really good surface put upon a road suitable for motor traffic under 4s. The estimated cost for the bottom and the surface came to 6s. 3d. per super yard. That was the cheapest rate that he could get for the construction of a road for heavy and fast motor traffic. Possibly since he obtained those estimates materials had cheapened ; but he must say that 2s. 3d. appeared to be a very low price for the satisfactory coating of a road for heavy motor traffic.

With reference to the width of main avenues and the recommendation of the Royal Commission, the 140 feet suggested had always been, in his opinion, too little. A main avenue should be at least 160 feet wide. 100 feet for a subsidiary road was a fair width.

Mr. Henry C. Adams said that the construction of roads formed the principal part of the work of the most skilled engineers in early days, but of recent years there had been very little construction, and the work of maintenance had devolved upon the highway surveyors. As a class they were highly skilled, but

he believed that they were absolutely the worst paid of any members of the municipal profession. It seemed to him that very great developments would take place owing to the working of the Road Act and that the old profession of road engineer would be to a great extent revived. With regard to the acquisition of land, he had always found in tramway work that it was necessary to schedule all land that might by any possibility be required, so as to be able to obtain it compulsorily if necessary ; but it was better to buy it without putting compulsion upon the owner, even if the buyer was squeezed a little bit.

The author went out of his way somewhat to praise the members of the Road Board. If the Road Board was locked upon as a committee of business men who were to criticise and control the professional zeal of the experts, it was all very good ; but they, as engineers, he thought, must look for the proper working of the Act to the advisory council which had been appointed, and with the composition of which nobody could find fault. If the Road Board took up the same attitude as the Board of Trade, and did not interfere in practical work more than that well known Board did, matters would go on satisfactorily.

Mr. Brewster said that with regard to conferences between the district surveyors and the county surveyor, it seemed to him that the county council should have its engineer, its district engineers, and its local engineers, and that there should be no municipal engineers for roads at all. The roads then would be formed under one body of men with one head, and these men would not then be subject to the caprices of butchers, bakers and candlestick-makers in the way in which many local surveyors now were, and the roads would be the better for such an arrangement.

The Act entitled the road authority to take one-eighth of a mile on each side of the centre of a roadway. That seemed to him to be rather an iniquitous provision, for, as he understood the Act, from the paper, the road authority could claim betterment, but that, although a man might be mulcted for betterment, nothing was to be paid to the owner of a property for its " worsement " by any so-called improvement that might be made.

He did not see in the paper any statement as to whether or not there was any time limit for paying off debts which might be incurred by local authorities. Perhaps the author would state what was the time limit, if any, provided for in the Act.

With regard to wear and tear, the author stated that one motor wagon had done an immense deal of harm to a road and that the owners had had to pay part of the expense of making up the road. He quite agreed that they ought to pay. But

why railway and canal companies should have to pay for enlarging or strengthening their bridges to meet the increased traffic and weight of vehicles passing over them he could not say. If the road authorities were paid for strengthening their roads then the railway and canal companies ought to be paid for strengthening and enlarging their bridges. It should not be forgotten that railway and canal companies paid rates and taxes ; and that they have to bear their share of any increased rates or taxes that may come upon any district through which they ran. It would not be just to penalise railway and canal companies for the benefit of the new heavy traffic going over their bridges.

With regard to the easing of gradients, it would be a very good thing if many people had their attention drawn to the way in which roads had been eased in the past by the old road engineers. A very great deal had been done in the way of easing the gradients of roads and in the speaker's judgment, but little remained to be done, except in special cases, now that mechanical traction was taking the place of horse traction. Stronger roads, however, were needed.

As to the width of roads, he had some knowledge of road making, and thought that it would be just as well to bear in mind that it was possible to have a road too wide for the traffic. There was not only the first capital cost of making a wide road ; but there was the cost of keeping up that road, for the maintenance would not be in proportion to the traffic when compared with a road of proper width, but greater.

Mr. J. A. Webb, dealing with the width of road, said that the Royal Commission recommended that main streets should be 140 feet in width. Those who had to deal with roads knew what difficulties there were in arranging for widths in excess of the requirements of district council by-laws. He knew of an instance in which an estate was laid out on the town-planning principle and in which the local by-laws provided that no street should be of a less width than 40 feet. The estate wanted to develop the land with carriageways varying in width and the local authority objected to the plans and disapproved of them. The estate then applied for an Act of Parliament and got one, and they made their main road 60 feet wide, and actually got permission for streets 20 feet in width with houses on either side. What was to be done in such a case ? The matter was a very difficult one. No one was more anxious to have a good width for carriage ways than local surveyors were. He only mentioned the instance which he had given in order to show the sort of difficulty with which surveyors had to contend.

With respect to conferences of local surveyors with the county surveyor, there were difficulties in the matter, and the business

was very complicated. The County Surveyor may hold meetings and appoint district committees, but was still placed in a peculiar position, as the surveyor to any Authority, if he had schemes of his own, would in justice to his own council undoubtedly recommend them before any others, however pressing they might be. The Road Board would have a very difficult task in deciding as to which were the most pressing needs.

As to dangerous corners, that was a subject in which he was particularly interested, because in his district there were some very dangerous corners, and there had been some very serious accidents at one corner in particular. The matter had been submitted to the Road Board for their consideration. He had recommended the council to widen the road for its entire length, a distance of about 160 yards; but the council, rather wisely, perhaps, said that it would cost a lot of money and that they would see what the Road Board were prepared to contribute, because if they contributed only a small amount the cost to the ratepayers would be very heavy.

Mr. A. Valon said that the author contemplated with apparent satisfaction the proposal that the expenditure on the roads should be borne in part by what he termed the extraordinary users of the road. It seemed to him (the speaker) that the doctrine of extraordinary user was a somewhat complicated and difficult one, because what was extraordinary at one time would probably be quite ordinary a few years later. He supposed that what the author desired was that those who used the roads should pay for the upkeep of them. At one time that principle was carried out very effectively by means of toll bars, but it had been found undesirable. He believed that good roads were necessary for the general welfare of the country, and that the cost of those roads should be borne by the general community and not by those who directly used them. The people who ran heavy motors for industrial purposes and so on might appear to obtain special benefit from good roads while also increasing the cost of upkeep; but still the advantage of their user went eventually to the whole of the community.

The author spoke about being able to get land by agreement with owners satisfactorily, but he (the speaker) was sorry to say that his experience was not the same as that of the author. He had always found that obtaining land for public purposes was a very expensive matter. Sometimes money was saved through getting land by agreement; but still the price paid for it was affected by the fact that when land was bought by compulsion the amount paid for it was very much higher than the real value of the land. Perhaps, now that land valuation was being carried out, it would be possible to purchase land at the value placed upon it in the valuation.

As to the relations between the central body and the district authorities, and between the council surveyors and the district surveyors, it seemed to him that what was wanted was a central department to deal with roads which went through several counties or through the country. Such roads ought to be taken entirely out of control of the local bodies.

When money was raised by one authority and partly spent by another it was generally spent badly. The local roads might well remain in the hands of the local authorities, but the through roads ought to be in the hands of a central department which had its own staff and which obtained its money from Imperial funds.

Mr. Cecil Nathan, referring to the suggestion of the author that some authority such as the County Council should act in conjunction with the Road Board in certain matters, said that if the Road Board were constituted a central department for controlling and financing the roads throughout the country, no doubt that suggestion could very well be carried out. The last speaker seemed to be in favour of the nationalisation of roadways. The advantage of this would be that under a central department all the funds raised would be under one control, and there was not the slightest doubt that, if a Road Board rate were levied so that all funds were paid to one central authority, the money could be expended very much more economically than it was spent at the present time. Would it not be well, until such a desirable arrangement came into force, for the Road Board to consider the drawing up of proper specifications for road construction and maintenance?

At the present time it seemed to him that Borough Surveyors were all vying with one another to reach an ideal, and that ideal seemed to be tar-macadam. All through the paper the author referred to tar-macadam. In one place the author stated that to the charge for repayment of principal and interest must be added the cost of treating the roads with tar-macadam, also the cost of treating the surface of the tar-macadam and dressing it annually. There were other things besides tar and tar-macadam. The present age seemed to be the tar age. Tar did not seem to him to be the best material for the purpose of binding together the macadam. Engineers who had had experience of tar must know that it was too subject to climatic conditions to be really an ideal waterproof binder. There were other materials, such as Lake Trinidad asphalt or Cuban asphalte, both of which had very large percentages of pure bitumen in them, and which, although they were slightly more expensive than tar, had a far longer life, and made a better bed for the stone. Tar, as was well known, was a very brittle substance in the winter, and in the summer it

retained its slimy lubricating character. A good asphalt was not subject to climatic influences in the same way that tar was.

As to the expenditure which the Road Board were making upon rounding off corners, it appeared to him that this expense ought to be borne by the local authorities. One would have thought that it was their business to attend to such matters without waiting for a Road Board to come forward. The money which the Road Board was at present collecting came from the motorists, and surely the motorists ought to have some consideration. If they were going to "pay the piper" they ought to "call the tune."

Many engineers did not know what the word "asphalt" really meant. They seemed to think that asphalt was the shiny slippery material which they saw in the streets of large towns, whereas that was not really asphalt at all. It was merely a bituminous siliceous limestone, which was put down in powder, and which had a skin put on it by a hot iron. He thought that asphalt-macadam was more likely to achieve the ideal than tar-macadam was. One speaker had stated that the price of 2s. 3d. a yard super for tar macadam was a very low price. He (the speaker) did not suppose that the cost of asphalt-macadam would exceed even that low price by more than about 50 per cent. Possibly 2s. 3d. was the price when the work was done on a commercial scale, but he hoped that sooner or later the roads, not only in the country but also in the towns, would be covered with asphalt-macadam, and not with tar-macadam, as the adoption of asphalt-macadam would soon repay the authorities who went to this expense. He knew the difficulty which borough surveyors had when they urged their councils to expend money upon more expensive methods involving greater initial outlay than had been previously adopted, the amount of money available being usually very limited, in spite of the fact that the surveyors could prove that such new methods were likely to be far cheaper in the long run.

Mr. T. E. Bower said that during the reading of the paper he had in his mind many of the roads in the north of England. The Romans who made the roads in the north of England were a different class of Romans to those who made the roads in the south. If they saw a hill in the north they went for the top of it, possibly for the outlook. It was a pity that there were not some North-country surveyors present to give us their experience who would be able to tell the meeting what asphalt would be like in many places in the North, for instance in such a place as Halifax, not only in the winter but at any time. If asphalt was used in Halifax, horses and motors would slip from the tops to the bottoms of the hills.

With regard to the socialistic treatment which the author wanted to deal out to railway and canal companies in connection with the widening of their bridges, the former of which had some difficulty in meeting its shareholders' demands, and the latter almost squeezed out of existence—these he thinks should be questions of arranged proportions between the companies and the Road Board. He would like to know what the views of the author were with regard to level crossings. There were a great number of these which were certainly very dangerous places. Who should pay for their alteration? In Doncaster, only recently, something like £80,000 (he believed) was spent in taking a viaduct over a level crossing. It was not possible for the engineers to get under the crossing, because of a canal, and the alternative was to go over. He believed that in that case two-thirds or three-quarters of the cost was borne by the railway company, and the remainder by the borough council, the work being carried out and proving a blessing to those who had to use the dangerous level crossing. The greater cost in this case was borne by the railway company because of the advantage they gained, as it enabled them to lay down four tracks in place of the existing two.

REPLY.

Mr. Reginald Brown, replying to the discussion, said, that with regard to the suggested conferences between the county surveyor and the district surveyors, it would have been far better to have had a conference between the county surveyor and the surveyor of each district authority. If the suggested arrangements were carried out there would be a meeting of thirty or forty surveyors from different districts of the county, and the county surveyor; and it was nonsensical to suppose that each individual surveyor would push his scheme in front of the schemes of his brother surveyors. It would be far better for a surveyor to lay his facts, quietly, before the county surveyor, and to let the county surveyor report to his county council. It had to be borne in mind that the Road Board had stated that schemes approved by the county councils would have first consideration.

He had not mentioned in the paper very much about the foundations of roads, but there was no doubt that the foundations were the most important thing, and it could not be expected that a road would last long if it had not a good foundation. There were at present many miles of road which would probably have to be entirely reconstructed.

As to the cost of tar-macadam, the whole question of road construction simmered down to the question of £ s. d. Asphalte or tar-macadam in its various forms, or tar slag macadam, could be used, but it was entirely a question of the amount of money which the local authorities were prepared to spend upon the

roads. There were some cases in which roads, quite close to towns, would have to be reconstructed with asphalt surfaces. The authorities in such places could stand the cost of reconstruction, because the present cost exceeded £500 a mile. Roads which cost £300 a mile could be resurfaced with tar slag macadam without any extra cost whatever.

They had been told by Mr. Meik that the lowest estimate that he could obtain for tar slag macadam for the proposed Motor Road was 4s. a yard ; but it must be remembered that the road referred to by Mr. Meik was an entirely new road. In many cases—for instance, in the case of a road built upon an embankment—the road was not properly consolidated in the first instance, and consequently a greater thickness than three inches would have to be put on the surface to make the road fit to carry motor traffic. A three-inch coating, compared with four inches laid down on a comparatively short length, would soon reduce the cost to 2s. 3d. if the work was carried out on 6,000 miles. Up to a particular point the bigger the area to be covered, the lower in proportion would be the cost of the road. To show that he was not far from the mark, he would mention the fact that he himself had had an offer for reconstructing and resurfacing a road to a thickness of three inches for a comparatively short area for 2s. 9d., with seven years maintenance. If he could get that for a small length, it was quite possible to get a figure of 2s. 3d. for 6,000 miles.

He quite agreed with what had been said about the width of main avenues. Everything depended upon £ s. d. If roads were going to be made 160 feet wide, more money would be required than for roads 140 feet wide ; but he thought that it would pay in the long run to make them 160 feet wide. One speaker had suggested that there would be an extra cost for maintaining the extra width ; but it must be remembered that the narrower the road the more costly it was to maintain. In a wide road the traffic was spread over a considerably larger area, and consequently the cost per square yard was comparatively low.

He quite agreed with the suggestion that land should be obtained voluntarily if possible, and not compulsorily, and he had always adopted the voluntary method as far as possible. He was thankful to say that he had been successful in obtaining very large improvements at no cost whatever to his council. He had found that the owners, when the matter was explained to them, had been quite prepared to give up their land to the council, without any cost at all to the ratepayers. If they were approached in the proper way they were always quite willing to fall in with the suggestions of the surveyor.

He thought that it would be a very big mistake to place all

the roads in the country under one central authority. Sufficient had been done by placing the main road under one authority for each county, without placing the whole of the main roads under one central body. What happened at the present time? The County Council maintained only the surface of the carriage-way through any parish. Certainly they did a little towards the path, but they said, "A gravel path is plenty good enough for our through traffic; if you want anything else your district will have to pay the whole cost of it, or a very large proportion." Why on earth that should be so he did not know. If a County Council insisted upon maintaining the main road, why should they not pay the whole cost of the path as well as of the roadway? In France there were "national roads," but there were roads in England as good—if not better—than in France.

As to the widening of railway bridges, that was a very important matter. The bridge which he had in mind when he wrote the paper was only 22 feet 9 inches wide between the parapets, and it was a bridge carrying what was practically a main road. It had been in existence for many years, and the railway company could not be called upon to widen the road to take the increased traffic. How had the increased traffic been brought about? In many instances it had been brought about by the railway company itself. The railway built a station and brought the public there, and also discharged the public in crowds on to the public highway, surely it was the duty of the railway company to help the local authority.

With regard to railway crossings, he quite agreed that the local authority should be prepared to pay a proportion of the cost of making improvements in connection with them. He did not say for a moment that the company should pay the whole of the cost, but railway companies should be expected to give money towards the widening of their structures. There was one way of getting over the difficulty in connection with the widening of bridges, and only one way. So far as he was aware, railway companies were bound under the Taff Vale decision to widen the bridge to the width of the approaches to the bridge. If a local authority would widen the approaches to 50 or 60 feet, they could call upon the railway company to widen the bridge to 50 or 60 feet.

The matter of tar-macadam and asphalt was entirely a question of £ s. d., but by all means let the authorities have an asphalt surface if they could afford to pay for it; but, of course, neither tar-macadam nor asphalt could be laid in such positions as those mentioned by Mr. Bower. No one would dream of putting asphalt or even tar-macadam upon some of the hills in Halifax. Asphalt could only be laid in suitable positions where there was an easy gradient.

It had been suggested by Mr. Nathan that the cost of rounding off corners should fall upon local authorities entirely, but he (the speaker) thought that it was necessary to look at the reason for rounding those corners. The rounding was really for the purpose of facilitating the motor traffic and for nothing else. The corners had been for many years in their present condition, but the increase of traffic which had come about through the use of motors had necessitated widening out the entrances to roads, and it was hardly fair to expect the local authorities of a poor district to widen corners for the benefit of somebody who came, perhaps, 200 or 300 miles from the district and did not pay a penny towards the rates of the parish. It was only fair that the cost should fall upon the general community and not upon the particular local authority. -

ANNUAL GENERAL MEETING.

The first Annual General Meeting of The Society of Engineers (Incorporated) was held at 17, Victoria Street, Westminster, on Monday, December 12th, 1910, the chair being taken by Mr. Diogo A. Symons (President).

The chairman announced the result of the postal ballot for the Election of Council and Officers for 1911 and the awards of premiums made in respect of papers published in the JOURNAL during 1910 (see page 295).

The Report of the Council for 1910 was taken as read and adopted (see next page).

Messrs. W. B. Keen & Company were re-elected as Auditors to the Society.

A vote of thanks to the Council and Officers for 1910 was proposed by Mr. Henry C. Adams, seconded by Mr. P. G. Scott, and carried unanimously.

A vote of thanks to the Scrutineers, for their services in connection with the ballot for the election of the Council for 1911, was proposed by Mr. C. T. Walrond, seconded by Mr. A. G. Drury, and carried unanimously. The proceedings then terminated.

REPORT OF THE COUNCIL FOR THE YEAR 1910.

Your Council have pleasure in reporting that the amalgamation of the Society of Engineers with the Civil and Mechanical Engineers' Society, and the incorporation of the new body, have had very satisfactory results.

Up to the present about 80 per cent. of the members of the old Societies have joined the incorporated Society. Among those who have not yet transferred their membership are several who have omitted to notify the Secretary of changes of address, and others who have neglected to sign the transfer form.

The publicity given to the amalgamation by the daily and technical press in the early part of this year produced a number of enquiries for particulars of the Society's work and resulted in over fifty applications for membership being received. The system of having a postal ballot for the election of corporate members has worked well and an unusually large proportion of the members voted in connection with the election of the Council for 1911.

The membership of the Society at the date of issuing this report is as follows :—Hon. Fellows 24, Fellows 69, Members 333, Associate Members 144 ; Total 570.

FINANCIAL.

The Society's Accounts will be prepared early in 1911 by Messrs. W. B. Keen & Co., the auditors appointed at the Annual General Meeting held on December 12th, 1910, and a copy of the Balance Sheet and Revenue and Expenditure Account will be issued to all the members as soon as possible after the completion of the audit.

INAUGURAL DINNER.

The amalgamation of the Society of Engineers with the Civil and Mechanical Engineers' Society and the inauguration of the Society of Engineers (Incorporated) was suitably celebrated at the Waldorf Hotel on January 19th, 1910, by a dinner at which a number of distinguished guests attended. The Chairman was Mr. E. J. Silcock, M.Inst.C.E., F.S.I., last President of the Society of Engineers, while Mr. W. Noble Twelvetrees, M.I.Mech.E., last President of the Civil and Mechanical Engineers' Society, occupied the vice-chair. Nearly 200 members and guests (including a number of ladies) were present.

INCORPORATION.

Although the amalgamation of the two constituent Societies dates from 1st January, 1910, the Incorporation was not completed until two months later. On February 16th, 1910, the Memorandum and Articles of Association were signed by sixteen representatives of the two Societies just amalgamated; the signed copies being forwarded to the Board of Trade on the following day. The licence of incorporation was received on February 23rd, 1910, and was filed with the Registrar of Joint Stock Companies 5 days later.

JOURNAL.

The monthly publication of the Journal and Transactions has met with the approval of the members and tends to keep them (especially those abroad) in closer touch with the Society's doings. In January, July, August and September of each year the opportunity occurs for the publication of papers which have not been read at an Ordinary Meeting, so that members who are unable to attend personally to read papers can nevertheless communicate their knowledge and experience to the Society. Such papers rank equally with others as regards the premiums awarded annually by the Council, and discussions in writing are received and published in subsequent issues. Offers of papers on engineering subjects will be welcomed, but intending authors should first apply to the Secretary for a copy of "Instructions to Authors."

PAPERS.

The Presidential Address of the first session was delivered by Mr. Diogo A. Symons, M.Inst.C.E., on Monday, February 7th, 1910, and will be found on page 25 of the JOURNAL.

The other papers published during the year were as follows:—

- "Electricity from the Wind," A. H. Allen, A.M.I.E.E.
- "Sewage Disposal Ideals," W. C. Easdale, M.R.S.I.
- "Moulmein Waterworks," Percy G. Scott, A.M.Inst.C.E.
- "Up-to-date Roads," R. O. Wynne-Roberts, M.Inst.C.E.
- "The Inspection and Testing of Engineering Materials and Machinery," C. W. V. Biggs, A.I.E.E.
- "Engineers and Empire Development," C. R. Enock, F.R.G.S.
- "Reinforced Concrete Retaining Walls," E. R. Matthews, A.M.Inst.C.E.
- "Some Engineering Troubles in Africa and their Solutions," G. A. Becks, A.M.Inst.C.E.
- "Current Professional Topics," Henry C. Adams, A.M.Inst.C.E.
- "Public Slaughter-houses," S. M. Dodington.
- "The Working of the Roads Development Act, 1909," Reginald Brown, A.M.Inst.C.E.

AWARD OF PREMIUMS.

The Council have awarded the following premiums in respect of papers read or published during 1910 :—

The President's Gold Medal, value £5 5s. 0d., to W. C. Easdale for his paper on "Sewage Disposal Ideals."

The William Clarke Premium, value £5 5s. 0d., to S. M. Dodington for his paper on "Public Slaughter-houses."

The Bessemer Premium, value £5 5s. 0d., to C. W. V. Biggs for his paper on "The Inspection and Testing of Engineering Materials and Machinery."

The Nursey Premium, value £3 3s. 0d., to Henry C. Adams for his paper on "Current Professional Topics."

A Society's Premium, value £3 3s. 0d., to A. H. Allen for his paper on "Electricity from the Wind."

A Society's premium, value £3 3s. 0d., to C. R. Enock for his paper on "Engineers and Empire Development."

THE "WILLIAM CLARKE" PREMIUM.

The Council wish to express their grateful thanks to Mr. William Clarke, M.Inst.C.E., Hon.F.S.E., formerly an Honorary Member of the Civil and Mechanical Engineers' Society, who has generously placed at the Council's disposal a premium of books and instruments to the value of Five Guineas, available for two years. This premium may be awarded by the Council to any member of the Society who on December 31st, 1909, was a member of the Civil and Mechanical Engineers' Society and who contributes a paper of sufficient merit which is read at an Ordinary Meeting or published in the JOURNAL.

THE "STATUS PRIZE."

The Status Prize is a premium of books and instruments which has been provided for five years for the best essay submitted each year on "How to improve the Status of Engineers and Engineering, with special reference to Consulting Engineers."

The Council regret that they could not make the award this year as the entries were few and below the standard of merit required. In 1911 the value of the prize will be Six Guineas, and it is hoped that there will be a competition worthy of the importance of the subject. Full particulars of the conditions may be had on application to the Secretary.

MEETINGS.

The work of the Society has necessitated 13 Council Meetings and 27 meetings of the various Committees. There have been eight Ordinary Meetings, six vacation visits and the Annual General Meeting.

VACATION VISITS.

Six visits to places of engineering interest were arranged during 1910 as follows :—

May 19th.—The printing works of Messrs. Cassell & Co., Ltd.

June 3rd.—The L.C.C. Tramways Central Repair Depot, Charlton.

June 15th.—The New London County Council Hall, Lambeth

July 12th.—The L.C.C. Northern Low-Level Sewer.

Sept. 7th.—The Thames Iron Works.

Sept. 21st.—The Naval, Mercantile Marine, and General Engineering Exhibition, Olympia.

The Council desire to express their thanks to those who kindly gave facilities for visiting the above.

LECTURES ON LAW.

Your Council, in conjunction with the Council of the Junior Institution of Engineers, arranged for the delivery of a series of lectures during the autumn months on "The Law relating to Engineering." The lecturer, Mr. L. W. J. Costello, M.A., LL.B. (Cantab), dealt very ably with his subject, but the attendance was not so good as might have been anticipated. It is proposed to issue the lectures in book form after the last of the series has been delivered.

AFFILIATION OF STUDENT SOCIETIES.

A scheme for affiliating Engineering Student Societies to your Society has recently been prepared, and your Council are now in communication on the subject with a number of Student Societies. It is anticipated that the result of this action will be mutually beneficial.

EMPLOYMENT REGISTER.

The Employment Register has been widely circularized and considerably used during the year, with the result that several appointments have been filled.

Unfortunately a number of those whose names have been on the Register have omitted to notify the Secretary of changes of address or that they have obtained suitable appointments, and, in consequence, it has been found necessary to require a deposit and to adopt more stringent rules with regard to notification of such changes.

Members are requested to make use of the register when requiring assistants, to recommend the register to their friends, and to notify the Secretary of vacant appointments that may come to their knowledge.

EXAMINATION FOR FELLOWSHIP.

A special committee has been engaged in drafting the particulars relating to the examination of candidates for election to the class of Fellows and it is hoped to issue the syllabus and regulations very shortly. It is practically settled, however, that the examination should be held in two parts; Part I. (theoretical); Part II. (practical) including a *viva voce* examination. For Part I. the minimum age limit will probably be 21 years, for Part II. 30 years.

Certain engineering degrees will be accepted in lieu of Part I., but, unless special merit can be shown, there will probably be no exemptions from Part II.

LIBRARY.

The Society exchanges transactions with the principal British, Colonial and Foreign Engineering Societies, while the leading engineering publications are on file in the Reading Room, and may be inspected by members. The Library contains the volumes formerly belonging to the Society of Engineers and the Civil and Mechanical Engineers' Society, to which several useful additions have been made during the year. The Council will be glad to receive new publications, which will be acknowledged in the Journal.

PAMPHLET *re* THE SOCIETY'S WORK.

A pamphlet has been issued dealing with the Society's origin, aims, constitution and advantages. It contains in concise form the leading details of the Society's history, the qualifications for membership, the benefits offered to members, and other particulars. Copies of the booklet can be obtained from the Society's offices, and will materially assist members when approaching their friends, as candidates for membership.

COUNCIL AND OFFICERS FOR 1911.

In connection with the postal ballot for the election of the new Council 156 voting papers were received and the scrutineers reported that the following candidates had been elected in accordance with the By-laws:—

As President: F. G. Bloyd.

As Vice-Presidents: John Kennedy, A. Valon, H. C. H. Shenton.

As Members of Council: Professor Henry Adams, C. T. Walrond, Norman Scorgie, Percy Griffith, T. E. Bower, Henry C. Adams, J. R. Bell, S. Cowper-Coles, Frank Latham, H. P. Maybury.

As Associate Member of Council: E. Scott-Snell.

As Hon. Secretary and Hon. Treasurer: D. B. Butler.

The Council wish to record their thanks to the Scrutineers,

Messrs. G. A. Becks and F. E. Davies, who kindly examined and reported upon the balloting papers.

CONCLUSION.

Your Council have reason to feel assured that the amalgamation of the constituent societies, the incorporation of the resulting body, and the provisions of the new constitution have the hearty approval of the members of the old Societies, and that the incorporated Society will fully justify the hopes entertained by its supporters. The new Society combines the prestige of an old foundation with the strength and vigour of a modern institution, and there is no doubt that the unique voting powers possessed by the corporate members will ensure the carrying on of its administration on sound lines and in accordance with the wishes of the majority of the members.

The Council urge on individual members the desirability of each one doing what lies in his power to ensure the continued success of a work so well begun. This may be effected by contributing or obtaining good papers, by proposing suitable candidates for election, by attending the meetings, visits and other functions as frequently as possible, and generally by displaying a lively personal interest in the Society's affairs.

Finally your Council wish to thank all those who have given their active or moral support to the Society during the past year.

17, *Victoria Street, Westminster, S.W*

12th *December, 1910.*

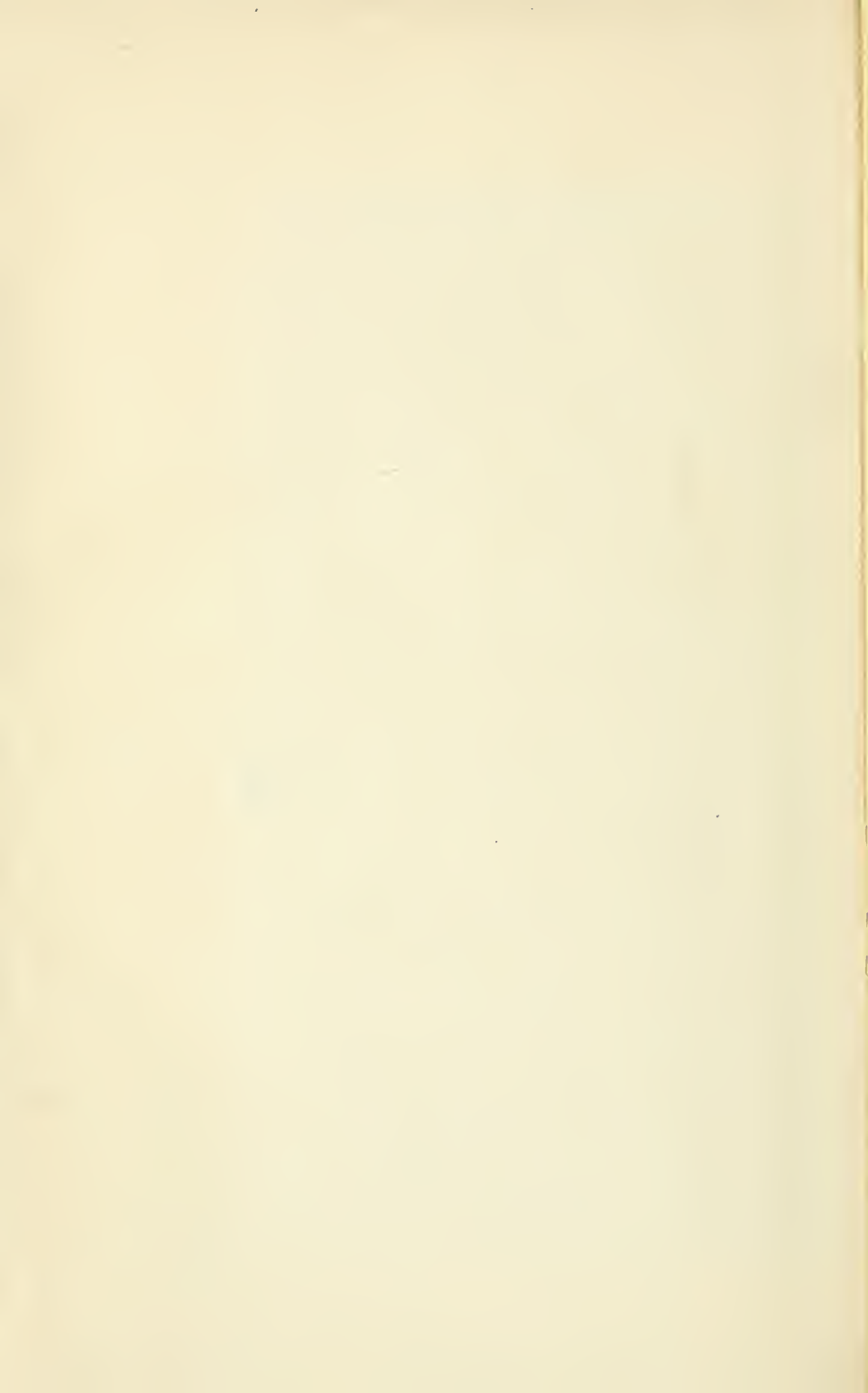
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NOTE.—A complete index to the Transactions of the old Society of Engineers will be found in the last volume published by that Society, and the volumes of Transactions of the Civil and Mechanical Engineers' Society also are indexed.

** Papers marked thus were awarded Premiums.*

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